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C. F. T. R. I.
FISH TECHNOLOGY EXPERIMENT STATION,
Hoige Bazaar, MANGALORE-1.
2/2/68

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*Editor :*

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*Director of Fisheries, Madras*

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# FOREWORD

The Madras Fisheries Department has been in existence from 1907. A great deal of scientific work has been done by persons working in the Department ever since its inception. Some of this work is contained in papers printed by the Department separately and some of it got incorporated in issues of the Fisheries Bulletins. In the recent years the scientific papers have been included in the successive issues of the Administration Reports of the Fisheries Department. The Director of Fisheries had therefore suggested that it would be highly desirable to have a separate Journal of Fisheries which could be printed and published by the Fisheries Department itself. The Government accepted this proposal and directed that the Department of Fisheries should publish a journal of its own to be called, "THE MADRAS JOURNAL OF FISHERIES". This is the first issue of the journal. I am very glad to find that it contains a number of scientific papers both of academic importance as also applied value. I hope that the Madras Journal of Fisheries will constitute a welcome addition to the growing volume of scientific literature produced in our country.

MADRAS,
31*st* *December* 1964.

GBhuvarahan

(G. BHUVARAHAN),
**Minister for Information and Publicity.**

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# BIOLOGY AND FISHERIES OF BARBUS DUBIUS (DAY) IN THE BHAVANISAGAR RESERVOIR

BY

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Huet (1959) relates the various problems in fish management to the Profile and Biology of Western European streams. He classifies European rivers into four zones, and zones comparable to these can also be distinguished in Indian rivers. The trout zones of brooks with deep gradient and rocky bottom are seen in our high altitude trout waters where cultural operations are practised. The greyling zone with rapids and pools, stream bed of pebbles, and boulders washed by current is comparable to our submountainous river stretch with a fishery of *Barbus tor*. The Barbel zone, an area alternating with rapid water and pools, stream with erosion and deposition banks, rocky and gravel beds alternating with sandy stretch, harbour the species—*Barbus dubius*, *Barbus carnaticus*, *Labeo kontius*, *Macrones aor* and *Wallagonia attu*. The last zone, viz., the Bream zone is typical of our deltaic stretches with slight water current, shallow sandy beds, and high summer temperature abounding in carps of the genera *Catla*, *Labeo* and *Cirrhina*. Many of the multipurpose reservoirs in India are constructed in the second or third zone listed above, originally impounding the fishes of the genus *Barbus*. Hence, a study of the Biology of the genus in the newly-formed reservoir conditions with special reference to growth and repopulation factors are of immediate practical importance. The effects of Dams on Fisheries have been discussed in a general way by Hora (1942, 1947, 1947-ab, 1948 and 1949) and Job et al (1955) and David and Motwani (1952).

Barber (1940) had observed thousands of fingerlings of *Barbus tor* ascending the provisionally constructed fish ladder at Mettur during the construction of the reservoir across the river Cauvery. There have been no catches of this species during all these years of exploitation at Mettur, in spite of the thousands impounded. *Barbus dubius* which was a favourite fishery in that river stretch and formed 5 per cent of the catches in the initial stage grew to good size, but failed to repopulate. The same fishery has successfully established itself in Bhavanisagar reservoir and it is also reported that it forms a good percentage of the landings from Krishnarajasagar.

There is no complete record of the Biology of any one of the species of *Barbus*. Observations on the breeding habits and migration of *Barbus tor* have been made by David (1953), Macdonald (1948), Hora (1940-b) and Wilson (1920). Hora and Nazir Ahamed (1946) records the suitability of *Barbus tor* and *Barbus hexagonolepis* for pond culture of the hilly tracts of Assam and East Bengal. Menon *et al* (1959) in their studies on the bionomics of the various fresh water fishes recorded that *Barbus dubius* formed 10 per cent of the fishery at Mettur and 60 per cent at Bhavanisagar. Very likely these observations relate to the period ended 1952 to which the report relates. Even then, the data for the figures from Mettur and Bhavanisagar do not justify this percentage. The particulars of fertilised egg and incubation period also do not seem to be correct and the distinguishing features by which the eggs were identified and worked upon are not furnished. The systematic position of the genus has been fully discussed by Hora (1940-b).

## Material and Methods.

The material for this investigation was available in plenty from the daily landings of the Bhavanisagar reservoir. The observations on food and feeding habits, age, growth and breeding habits are with reference to this ecological condition. Comparisons were also made with the specimens collected from the river system above and below the Dam. From 1955 onwards specimens of *Barbus dubius* numbering over 25,000 have been examined at various stages. Specimens with mutilated caudal fins were rejected (Seshappa and Bhimachar 1955). Measurements of length were taken correct to the nearest millimetre and in the fresh condition. The total length was taken from the tip of the snout to the end of the longest caudal ray. Besides the length, the individual weights were also recorded. Histograms of these lengths were drawn to have an idea of the trend of this fishery in the newly impounded reservoir. Since 1961 scales were taken from all specimens from the left side of the body below the dorsal fin and above the lateral line, recording simultaneously the total length, gonadial condition and stomach contents. Regenerated scales were discarded and only the best scales were selected. After clearing, they were mounted on a glass slide and examined under a powerful lens. The scales were also projected and the length of the scales, anterior radius (from the focus to the anterior edge) and the distance between the focus and each year ring were all measured to the nearest millimetre.

## Description of the Bhavanisagar Reservoir.

The Bhavanisagar reservoir has a water spread of 30·41 square miles at the full reservoir level of 920 feet M.S.L. impounding 28,000 million cubic feet of water. It is formed by the damming the river Bhavani after its confluence with river Moyar, both arising from the Nilgiris (Fig. 1). The average yearly inflow of the two rivers is 1,000 cusecs. During the South-West Monsoon (June to August) and North-East Monsoon (November to January) the inflow increases to 10,000 cusecs and this has an important bearing on the repopulation of the fishes breeding both in South-West and North-East Monsoon periods. The bed level of river Moyar as it enters the reservoir is

905 M.S.L. and it gradually slopes down to 805 M.S.L. as it joins the river Bhavani. The M.S.L. of the river bed after its confluence at the Dam site is 802. The bed level of the river Bhavani as it enters the reservoir is 905. There are no falls or barriers at the commencement of the reservoir. At various contour levels, the spread of the water in relation to the entry of the river into the reservoir is such that there are no falls or barriers preventing the free migration of fish to the river stretch above. The sill level of the exit regulators of the canal after damming is + 840 and this ensures a perennial storage in spite of adverse conditions. The following are the details of water storage and spread at different levels :—

| *Contour level.* | *Area submerged in acres.* | *Water storage in M.C.F.T.* |
|---|---|---|
| (1) | (2) | (3) |
| + 840 M.S.L. .. .. .. | 1,608·3 | 5,461 |
| + 880 .. .. .. .. | 8,594·8 | 8,879 |
| + 915 .. .. .. .. | 17,955·85 | 28,726 |
| + 920 .. .. .. .. | 19,463·80 | 32,799 |

The dispositions of the contour lines of 920 feet, 915, 880 noted in the sketch (Fig. 1) give an indication of the terrain of the area submerged. A few depressions on account of mountain feeder streams joining the original river are seen. The north-east half of the submerged Moyar spread was once a reserved forest now completely denuded, and operation of drift nets at all contour levels is easily possible. Between the dam and the river Moyar is the old Peerkadavu village. The western area submerges the old Dananarankottai village, with its temple and is bounded by the eastern slopes of the Nilgiris which slopes to the Bhavani river bed level from 930 to 820, the contour line taking some changed course on account of the hilly area. The eastern half of the reservoir has the same sloping contour gradually leading to the Panchayat Forests and the village. Except for the submerged temple and a few rocky hills getting exposed at various levels, there are no fishing impediments at any contour level. The two rivers have a long river stretch above the reservoirs. Emerging out from the hills, they are fast flowing rivers with rapids and pools, beds strewn with pebbles and occasional sandy patches. Wilson (1920) has recorded the importance of this stretch as breeding grounds of fishes for conservation. *Barbus tor*, *Barbus hexagonolepis*, *Barbus dubius*, *Barbus carnaticus*, *Labeo kontius*, *Labeo ariza*, *Wallagonia attu*, *Macrones aor*, *Macrones seenghala* and *Ophiocephalus striatus* are the fishes of economic importance recorded by various workers of the Madras Fisheries in this stretch as well as the now submerged river stretch.

## An Account of the Fishery of the Reservoir.

The reservoir impounded water since 1955. The fishery is now conserved along with a programme of stocking with the well known Indian Carps Rohu, Mrigal and *Catla*. Since 1957 a unit was made to fish daily at various places marked in the map. The unit consisted of four fisher men laying 2,500 running feet of synthetic yarn Rangoon nets of varying meshes and hauling them up next morning. The catches were analysed in detail, length of each fish recorded and the gonadial condition observed. An analysis of these observations is expected to reveal the trend of growth and repopulation of each species-indigenous and exotic to the reservoir and of practical application in the management programme of the multipurpose reservoirs. The following are the more important species of fishes, their numbers and weight landed by the experimental unit. It is seen that the trend of *Barbus dubius* fishery is one of growth and repopulation. The histogram picture of 2,000 fishes, in 1957 (Fig. 2) reveals a limited exploited age group while the 1961 (Fig. 4) picture shows age groups of all the VI year classes. In view of the space offered, planktonic food and the benthic fauna on the margins, there was quick growth. Since, by 1957 the reservoir was two year old the exploited group ranged up to the fourth year class. By 1961 (Fig. 4) the V, VI and VII year classes have appeared as was expected. The fishery constitutes 1/5 of the total fishery and thus assumes major importance in reservoirs of the Bhavanisagár type (Photo 1).

*Quantity and species of fish landed by the experimental unit at Bhavanisagar.*

| *Year.* | *Barbus dubius.* | | *Macrones aor.* | | *Labeo fimbriatus,* | | *Labeo calbasu,* | | *Catla catla,* | | *Wallago attu,* | | *Labeo kontius,* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Number.* | *Weight in Kg,* | *Number,* | *Weight in Kg,* | *Number,* | *Weight in Kg,* | *Number,* | *Weight in Kg,* | *Number,* | *Weight in Kg,* | *Number,* | *Weight in Kg,* | *Number,* | *Weight in Kg,* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| 1956–57 .. | 4,015 | 4,838·9 | 4,428 | 713·0 | 13 | 15·2 | .. | .. | .. | 64·3 | .. | .. | 102 | 865·22 |
| 1957–58 .. | 2,805 | 4,667·5 | 847 | 2,380·0 | 215 | 15·65 | .. | .. | 9 | 88·5 | .. | .. | 125 | 88·9 |
| 1958–59 .. | 2,344 | 4,542·6 | 514 | 849·3 | 28 | 20·9 | .. | .. | .. | .. | .. | .. | 128 | 91·2 |
| 1959–60 .. | 2,166 | 4,425·0 | 1,152 | 2,230·5 | 170 | 585·4 | .. | .. | 43 | 558·0 | .. | .. | 273 | 294 |
| 1960–61 .. | 2,882 | 5,219·0 | 3,367 | 6,152·0 | 620 | 1,479·0 | 318 | 1,203·8 | 134 | 1,203·8 | 453 | 581·2 | 324 | 356·3 |

## Food and Feeding Habits.

Over 250 specimens of the fish were examined to determine its food and feeding habits. The fish has a protrusible mouth very typical of the Masheer family and adapted to hill stream conditions. This adaptation helps it to turn, the pebbles, sand and mud and feed on fresh water Oligochaetes, Chironemids, and gastropods. In addition, it also feeds on the Zoo andPhyto-plankton in the reservoir *Pediastrum*, *Nitzchia*, *Navicula* and *Melosira* being more common. The gill rakers are slightly developed to filter the plankton organisms. There are well developed buccal glandular thickenings secreting mucous to guide the filtered plankton food to the pharynx. The guts of the specimens during October to December are not always full. Plankton food is more dominant during these months and there is very little of the bottom fauna. From January onwards the fishes commence an active feeding period usually shoaling along the margins and in the top waters at a depth of 5 to 15 metres. The alimentary canal of these specimens at this stage is clogged with Chironomids, fresh water oligochaetes, gastropods, and broken insect wings and appendages. There is no reason to suggest any direct relationship between the occurrence of any special type of food forms in the reservoir or top waters leading to mass migration. In general, the fish is a bottom feeder and restricts itself to the 5 m. to 15 m. belt of the reservoir rich in chironomids, fresh water oligochaetes and gastropods and also helps itself to all the available plankton food in the reservoir (Chacko 1956).

## Age and Growth

A knowledge of the year class composition of *Barbus dubius* fishery is extremely important for studying its trend and to decide the management policy. This is possible only if the age and growth are determined. The age and growth of *Barbus dubius* have been studied by the following methods :—

(i) By analysis of the length frequency distribution of the catches from the experimental unit at Bhavanisagar; and

(ii) by a study of certain rings that occur in the scales of this fish and which have been found to be indicators of age. Scales have been used for the estimation of age of tropical fishes with varying degress of success, Jhingaran (1959) Pantulu (1961) Seshappa and Bhimachar (1954 and 1960). The rings occured repeatedly in all specimens of 250 mm. and above. It was considered useful to find out reliably the exact frequency of the occurrence of these rings in the different size groups and several random samples were examined in detail. The information obtained from 30 of the 180 observations is summarised below:—

| *Length of fish in mm.* | *Radius in mm.* | *Number of rings.* | *Distance from the centre.* |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 300—309 .. .. | 4·5 | 2 | 4·5 |
| 310—319 .. .. | 4·5 | 2 | 4·5 |
| 320—329 .. .. | 4·7 | 2 | 4·7 |
| 330—339 .. .. | 5·0 | 2 | 5·0 |
| 340—349 .. .. | 5·0 | 2 | 5·0 |
| 350—359 .. .. | 5·5 | 2 | 5·0 |
| 360—369 .. .. | 5·7 | 2 | 5·0 |
| 370—379 .. .. | 6·0 | 2 | 5·0 |
| 380—389 .. .. | 6·3 | 2 | 5·0 |
| 390—399 .. .. | 6·3 | 2 | 5·0 |
| 400—409 .. .. | 6·5 | 2 | 5·0 |
| 410—419 .. .. | 6·7 | 2 | 5·0 |
| 420—429 .. .. | 6·7 | 2 | 5·0 |
| 430—439 .. .. | 7·0 | 3 | 7·0 |
| 440—449 .. .. | 7·2 | 3 | 7·0 |
| 450—459 .. .. | 7·5 | 3 | 7·0 |
| 460—469 .. .. | 7·5 | 3 | 7·0 |
| 470—479 .. .. | 7·9 | 3 | 7·0 |
| 480—489 .. .. | 8·3 | 3 | 7·0 |
| 490—499 .. .. | 8·5 | 3 | 7·0 |
| 500—509 .. .. | 8·5 | 3 | 7·0 |
| 510—519 .. .. | 9·1 | 4 | 9·0 |
| 520—529 .. .. | 9·3 | 4 | 9·0 |
| 530—539 .. .. | 9·5 | 4 | 9·0 |
| 540—549 .. .. | 9·5 | 4 | 9·0 |
| 550—559 .. .. | 9·7 | 4 | 9·0 |
| 560—569 .. .. | 10·1 | 5 | 10·0 |
| 570—579 .. .. | 10·2 | 5 | 10·0 |
| 580—589 .. .. | 10·3 | 5 | 10·0 |
| 590—599 .. .. | 10·5 | 5 | 10·0 |
| 600—609 .. .. | 11·0 | 5 | 10·0 |
| 610—619 .. .. | 11·2 | 6 | 11·0 |
| 620—629 .. .. | 11·3 | 6 | 11·0 |
| 630—639 .. .. | 11·5 | 6 | 11·0 |
| 640—649 .. .. | 11·0 | 6 | 11·0 |
| 650—659 .. .. | 11·8 | 7 | 11·8 |
| 660—669 .. .. | 12·0 | 7 | 12·0 |
| 670—679 .. .. | 12·0 | 7 | 12·0 |
| 680—689 .. .. | 12·3 | 7 | 12·0 |

There were no rings in specimens below 250 mm. The scales of *Barbus dubius* are ovolanceolate in shape with a central granulated nucleus. A camera luicida drawing of the scale Fig. 16. with the growth ring is figured in the diagram. The rings appear clearly during the breeding period October to December and from January onwards, the scales develop uniformly and actively beyond the rings. The correlation of the rings to the 'breeding' stress is interesting inasmuch as no environmental lack of food has been observed. Menon and Krishnamoorthy (1956) tried to determine its age and growth. Whatever may be the cause of the variation in the rate of growth leading to the ring formation, the fact remains that the ring is annual in nature and can be used in determining the age of the fish. From the table already presented, the length of the rings from the focus is derived as follows :—

| | |
|---|---|
| I Ring .. .. .. .. | 3 m.m. |
| II Ring .. .. .. .. | 5 m.m. |
| III Ring .. .. .. | 7 m.m. |
| IV Ring .. .. .. | 9 m.m. |
| V Ring .. .. .. .. | 10 m.m. |
| VI Ring .. .. .. | 11 m.m. |
| VII Ring .. .. .. | 12 m.m. |

The observed mean length, range and its relationship to the annulus is expressed in the following table:—

| *Annulus.* | *Age in years.* | *Mean length in m.m.* | *Range in mm.* |
|---|---|---|---|
| 1. | I | 250 | 0—270 |
| 2. | II | 360 | 270—390 |
| 3. | III | 440 | 380—470 |
| 4. | IV | 520 | 450—540 |
| 5. | V | 570 | 510—590 |
| 6. | VI | 620 | 570—630 |
| 7. | VII | 670 | 620—680 |

It would appear that the first ring is seen in fishes of average length 250 mm. Second 360 mm. Third 440, fourth 520, fifth 570, sixth 620 and seventh 670.

### Body Scale Relationship.

The reliability of the above data were tested against a detailed study of the body scale relationship. The length of the scale increases with the increase in length of fish. This is illustrated in the Text Fig. 5 which shows a straight line relationship. This relationship is expressed by the general formula.

$Y=a+bx$. where ;
$Y$=Length ;
$X$=Scale Radius and ;
a and b are constants.

In this present work, the regression formula was calculated to be

$L=139{\cdot}36+43{\cdot}7x$
$L$=Total length of fish; and
$X$=Scale Radius.

In Fig. 6, this straight line cuts the Y axis at 139 mm. In this population, it is determined that the scale radius is visible when the fish is about 139 mm. in total length. This was actually found to be correct in *Barbus dubius.* The radius is visible when the fry are 139 to 140 mm. and proves the correctness of the formula.

Using this regression formula, back calculation was made to find out the lengths reached by the fish at the formation of various rings. [Fig. 7.]

### Calculated Lengths are given below :

| | |
|---|---|
| I Year .. .. | 270 m.m. |
| II Year .. .. | 357 m.m. |
| III Year .. .. | 445 m.m. |
| IV Year .. .. | 532 m.m. |
| V Year .. .. | 573 m.m. |
| VI Year .. .. | 619 m.m. |
| VII Year .. .. | 660 m.m. |

The comparison between the observed lengths from size, frequency and ring groups and calculated lengths of fish is expressed in the following table:—

| *Age in year.* (1) | *Observed length from Histogram* M.M. (2) | *Observed length from Ring Groups* M.M. (3) | *Calculated length* M.M. (4) | *Number of Ring.* (5) |
|---|---|---|---|---|
| I .. .. .. | 250 | 250 | 270 | 1 |
| II .. .. .. | 350 | 360 | 357 | 2 |
| III .. .. .. | 430 | 440 | 445 | 3 |
| IV .. .. .. | 510 | 520 | 532 | 4 |
| V .. .. .. | 570 | 570 | 573 | 5 |
| VI .. .. .. | 610 | 620 | 619 | 6 |
| VII .. .. .. | 660 | 670 | 660 | 7 |

*Agreement with Peterson's method.*—Agrement with Peterson's method is one of the tests of validity for the use of any structure for age and growth determination. As is well known, in a population of a species of fish having a single restricted spawning season, the individual lengths of fish of each age group are approximately normally distributed and the modes of the length frequency distributions of successive age groups in a sample are separated along the length axis. In *Barbus dubius* these conditions are almost completely satisfied in that the fish has a single spawning season, during October to December. A frequency diagram of 2,000 specimens collected during all the months for the year is shown in Text Fig. 4 The different age groups in the polymodel frequency distribution were separated by the eye method (M.D. & B.K.). The 'O' group individuals were not represented in the length frequency histogram as they formed the prerecruit phase in the fishery and hence did not appear in commercial catches. As is evident from the table there is a high degree of agreement between age estimation, by the scale method and length frequency studies.

The observed mean lengths, calculated lengths and the radius of the scales is illustrated in Fig. 6.

### Growth in Length.

The table below (Table IV) presents the growth in length and its increments at the end of each year and is further illustrated in Text Fig. 7 (*a*) and 7 (*b*).

The growth increment in length of *Barbus dubius* fish decreases in the second year and it increases in the third or fourth year. After that the growth gradually decreases.

TABLE IV.

| *Age* | *Average length in m.m.* | | | | | | | *Average increment in m.m* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Groups.* (1) | I (2) | II (3) | III (4) | IV (5) | V (6) | VI (7) | VII (8) | I (9) | II (10) | III (11) | IV (12) | V (13) | VI (14) | VII (15) |
| II .. | 230 | 334 | | | | | | 239 | 95 | | | | | |
| III .. | 206 | 308 | 424 | | | | | 206 | 102 | 116 | | | | |
| IV .. | 183 | 304 | 402 | 463 | | | | 183 | 121 | 98 | 61 | | | |
| V .. | 197 | 296 | 420 | 500 | 561 | | | 197 | 99 | 124 | | 61 | | |
| VI .. | 151 | 300 | 404 | 514 | 578 | 624 | | 151 | 149 | 102 | 110 | 64 | 46 | |
| VII .. | 156 | 298 | 387 | 491 | 573 | 626 | 670 | 156 | 142 | 89 | 104 | 82 | 53 | 46 |

### Length–Weight Relationship.

In order to find out the length weight relationship the individual weights and measurements of 100 specimens ranging from 300 mm. to 680 mm. were recorded. These 100 fishes were divided into 6 groups. The average length and weight for each group were calculated. A scattered diagram of weight and length (Text Fig. 8) suggested that the relationship conformed to the general formula.

$W=CLn$. where,
$W$=Weight,
$L$=Length and,
$C$ and $n$ are constants.

The logrithamic formation of this equation is,

$\text{Log } W = \log c + n \log L$.

The value of log 'c' and 'n' were determined from the following normal equation :—

$$\text{Log } c=\frac{\Sigma \log W.\ \Sigma (\log L)^2 - \Sigma \log L\ (\Sigma \log L.\ \log W)}{N.\ \Sigma (\log L)^2 - (\Sigma \log L)^2}$$

$$\text{and } n=\frac{\Sigma \log W - N \log C}{\Sigma \log L.}$$

In this present work the equation worked out to $\log W=7{\cdot}333+3.878 \log L$.

Text Fig. 8 illustrates the calculated weights against the lengths.

**Growth in Weight.**

The table below shows the increment of fish in weight at the end of each year. It shows that the fish grows in weight rapidly from the second year onwards. This increment in weight is illustrated in the Text Fig. 9 and 10.

TABCE V

| Age Groups. | Average weight in grams. | | | | | | | Average incrment in grams. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | I | II | III | IV | V | VI | VII |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | 15) |
| II .. | 77 | 355 | | | | | | 77 | 278 | | | | | |
| III .. | 44 | 207 | 719 | | | | | 44 | 163 | 512 | | | | |
| IV .. | 28 | 198 | 585 | 1,016 | | | | 28 | 170 | 387 | 431 | | | |
| V .. | 37 | 178 | 687 | 1,371 | 2,623 | | | 37 | 141 | 509 | 684 | 1,252 | | |
| VI .. | 18 | 187 | 585 | 1,583 | 2,495 | 3,214 | | 18 | 169 | 398 | 953 | 957 | 719 | |
| VII .. | 15 | 182 | 498 | 1,250 | 2,275 | 3,214 | 4,236 | 15 | 167 | 316 | 752 | 1,025 | 939 | 1,022 |

**Relative Condition.**

Relative condition factor or Kn was calculated by using the formula $K=\frac{W.10^5}{L^3}$ It was calculated for individual fish, of six groups, Table VI.

The table VII presents calculated K factor for individual fishes, male and female separately for the months of October, November, December and January.

TABLE VI.

RELATIONSHIP BETWEEN LENGTH AND WEIGHT OF BARBUS DUBIUS.

| Number of years. (1) | Mean weight in grams (2) | Mean length in m.m. (3) | $K=\frac{W{\cdot}10^5}{L^3}$ (4) |
|---|---|---|---|
| 1, 2 .. .. .. .. | 455 | 363 | 0·9513 |
| 2, 3 .. .. .. .. | 975 | 445 | 1·109 |
| 3, 4 .. .. .. .. | 1,527 | 515 | 1·118 |
| 4, 5 .. .. .. .. | 2,335 | 577 | 1·215 |
| 5, 6 .. .. .. .. | 3,017 | 619 | 1·272 |
| 6, 7 .. .. .. .. | 3,505 | 675 | 1·140 |

Compared to other carps the gonads occupy very little space and form a very small portion of the weight of the adult fish as a whole.

The ground averages of K. are presented below. It shows that the relative condition is less than '1' in the second year. From second year onwards it increases gradually and reaches its maximum value in fourth to fifth to sixth year. From sixth year onwards, it decreases.

Comparison of this table V with the Text Figs. 9 and 10 shows that the growth in weight reaches its maximum value in the fifth year which coincides with the greater value of K. at that age.

TABLE VII.

| Month. | Male. | | | | Female. | | | |
|---|---|---|---|---|---|---|---|---|
| | Number, | Length, m.m. | Weight, g.m. | K | Number, | Length, m.m. | Weight, g.m. | L, |
| (1) | (2) | (3) | (4) | (5) | (6) | (6) | (8) | (9) |
| October .. .. | 1 | 405 | 700 | 1.053 | 1 | 345 | 400 | 0·8574 |
| | 2 | 430 | 800 | 1.006 | 2 | 360 | 400 | 0·8574 |
| | 3 | 536 | 1,500 | 0·9738 | 3 | 527 | 1,650 | 1·127 |
| | 4 | 575 | 2,500 | 1·314 | 4 | 530 | 1,600 | 1·074 |
| | 5 | 645 | 3,400 | 1·267 | 5 | 576 | 2,250 | 1·178 |
| | | | | | 6 | 605 | 3,100 | 0·705 |
| | | | | | 7 | 614 | 3,000 | 1·296 |
| | | | | | 8 | 680 | 4,500 | 1·431 |

| Month. | Male, Number, | Male, Length, m,m, | Male, Weight, g,m, | Male, K. | Female, Number, | Female, Length, m,m, | Female, Weight, g,m, | Female, L. |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| November .. .. | 1 | 448 | 1,000 | 1·112 | 1 | 435 | 900 | 1·093 |
| | 2 | 480 | 1,200 | 1·086 | 2 | 505 | 1,500 | 1·165 |
| | 3 | 494 | 1,000 | 0·644 | 3 | 555 | 2,200 | 1·286 |
| | 4 | 545 | 1,700 | 1·079 | 4 | 610 | 2,500 | 1·162 |
| | 5 | 590 | 2,600 | 1·269 | | | | |
| | 6 | 645 | 3,500 | 1·304 | | | | |
| December .. .. | 1 | 445 | 1,000 | 1·134 | 1 | 410 | 800 | 1·161 |
| | 2 | 550 | 1,700 | 1·052 | 2 | 420 | 800 | 1·144 |
| | 3 | 570 | 2,000 | 1·000 | 3 | 460 | 1,050 | 1·104 |
| | | | | | 4 | 520 | 1,600 | 1·138 |
| | | | | | 5 | 665 | 3,000 | 1·021 |
| January .. .. | 1 | 295 | 400 | 1·559 | 1 | 422 | 850 | 1·331 |
| | 2 | 435 | 600 | 1·042 | 2 | 450 | 1,300 | 1·427 |
| | 3 | 435 | 850 | 1·032 | 3 | 452 | 1,000 | 1·083 |
| | 4 | 460 | 1,000 | 1·027 | 4 | 460 | 1,100 | 1·130 |
| | 5 | 462 | 1,100 | 1·116 | 5 | 465 | 1,150 | 1·144 |
| | 6 | 482 | 1,300 | 1·135 | 6 | 480 | 1,300 | 1·176 |
| | 7 | 492 | 1,400 | 1·250 | 7 | 510 | 1,500 | 1·193 |
| | 8 | 500 | 1,400 | 1·119 | 8 | 515 | 1,500 | 1·098 |
| | 9 | 520 | 2,300 | 1·639 | 9 | 530 | 1,900 | 1·277 |
| | 10 | 560 | 2,200 | 1·252 | 10 | 630 | 3,000 | 1·111 |
| | 11 | 597 | 2,310 | 1·085 | 11 | 635 | 3,000 | 1·092 |
| | 12 | 615 | 3,100 | 1·332 | 12 | 650 | 3,000 | 1·384 |
| | 13 | 642 | 3,600 | 1·352 | | | | |

**Maturation, Fecundity and Spawning.**

The scale adopted by Hjort was followed to distinguish the different stages in the maturity of the fishes. The fishes attain maturity only once in a year with a marked spawning season extending from October-November to December coinciding with the North East Monsoon. The species become gravid only from the second year onwards. They do not spawn in the reservoir but migrate upwards and spawn in the river stretch. The males ripen earlier and start their upward migration and are followed by the females. Because of this, there is an apparent percentage difference of sex ratio in the catches. The October catches are predominantly male while the December catches are female. However, after the spawning season is over, the catches exhibit an equal number of females and males. Stage I of maturity in females is seen in the catches of late September. By the end of October, stage V is reached. Once the North East Monsoon sets in and the floods come, upward migration starts and the spawning grounds are full of breeders. On gentle pressure, the ova come out, the individual ovum being transparent and ripe. So far as Bhavanisagar is concerned the spawning grounds are easily accessible irrespective of the water spread. The grounds are the river stretch immediately above the reservoir. The mature adults take shelter in the clear pools between two shallow rapids. Fishes caught from these pools are in VI stage. On handling the ripe ova run out and fish lends itself to stripping and artificial fertilisation.

This sexual dimorphism of the fish has been described by Choodamani and Thyagarajan (1959.)

| | Male. | Female. |
|---|---|---|
| Pearl organs (Tubercles on the cheek). | Large member and greatly enlarged | Few and nil in large specimens. |
| Anal fin .. .. .. | Smaller than pectorals and equal to or smaller than ventrals. | Larger than both pectorals and ventrals. |
| Ventral .. .. .. | Smaller than pectorals and equal to or slightly larger than anal, | Smaller than both anal and pectoroal, |

Their statement that in *Barbus dubius* females attain bigger size than the males is not borne out by our observations in the reservoir.

The pronounced appearance and even enlargement of the tubercles as maturity advances in males is marked. During spawning, a translucent plate bearing the impression of the tubercles peels off, from the cheeks. The just spawned males can be easily identified by the fresh surface of the tubercular cheek. No such peeling off is observed in females.

## Fecundity.

The fecundity of the fish is poor compared to other major Indian Carps. The following are the estimated number in four of the females collected near the spawning ground :—

| *Length of the fish.* (1) | *Weight in grams.* (2) | *Volume of ovary.* (3) | *Weight of ovary.* (4) | *Number of ova.* (5) |
|---|---|---|---|---|
| | | cc. | gr. | |
| 603 .. .. .. | 3,650 | 85 | 87 | 66,568 |
| 612 .. .. .. | 3,668 | 88 | 92 | 65,340 |
| 608 .. .. .. | 3,614 | 80 | 78 | 65,480 |
| 605 .. .. .. | 3,645 | 78 | 72 | 65,279 |
| 617 .. .. .. | 3,712 | 92 | 88 | 66,417 |

Alikunhi (1954) has recorded the fecundity of some species of carps as follows :—

| *Species.* (1) | *Total weight in grams,* (2) | *Number of ova,* (3) |
|---|---|---|
| *Catla Catla* .. .. | 5,107·5 | 400,275 |
| *Labeo Rohita* .. .. | 4,653·5 | 1,905,000 |
| *Labeo Calbasu* .. .. | 1,816·0 | 739,400 |
| *Cirrhina Mrigala* .. | 1,475·5 | 216,800 |
| *Labeo bata* .. .. | 1,049·9 | 300,000 |

He has brought out the sizeable percentage of the ovary by weights and volume to the total weight of fish in the major carps.

The ripe ovary is inconspicuous in *Barbus dubius* compared to the weight of the fish. The gonadial maturity and sex affect very little the length weight relationship at any stage.

*Spawning.—Barbus dubius* spawns once in a year between October and December during the North East Monsoon. The fish exhibits a marked spawning migration. The favourite spawning grounds for the Bhavanisagar fishes are marked in Text Fig. 1. After taking shelter in the pools they move towards shallow areas and deposit the egg in batches in the gravel. Each batch consists of 1,000 to 2,000 eggs. At this stage, the fish are lethargic and are easily caught by the fishermen with their stringless cast nets and by diving. Even on handling, the milt and ova are shed out.

The river water here is characterised by high oxygen content, supersaturation as seen in the table. The substratum is full of pebbles and coarse grains.

*Hydrological data of the Spawning Belt from where Oozing Breeders were Collected for Stripping.*

Date—18th September 1960.
Time—11·00 a.m,
Temperature—27·8° C.
Free Co2—1·4 P.P.M.
Carbonate—Nil.
Bicarbonates—15·25 P.P.M.
Chloride—9·00 P.P.M.
Oxygen—9·8 Ms/L.
Oxygen per cent Saturation—120 per cent.
pH—6·7

(*Water slightly turbid*)

The fishery management at this stage calls for a complete prohibition of the top waters from any type of fishing. Heavy catches, by local fishermen, of 250 K g. a day were recorded of oozing *Barbus dubius* on many days in October and November 1960 and 1961. According to Chacko (1956) '*Barbus dubius*' migrates upstream during the floods of both the monsoons and spawns in the higher reaches of the river where the temperature is about 27°–30°C. and pH 8.0–9.8. The pH of a natural flowing water in the submountaionous area cannot be so high. Our observations at Bhavanisagar clearly reveal that the fish spawns only once in a year corresponding to North–East Monsoon.

## Development.

A complete picture of the developmental stages was made possible by artificial stripping and fertilising the oozing adults caught from the spawning bed. A number of hatchlings were also collected from "reds" in the spawning area and reared for a month in the laboratroy and correlated with the stages reared from stripping.

The fertilised egg is perfectly spherical, with a glossy appearance of blue orange yellow. The phenomenon of swelling of the eggs after fertilisation observed in Indian Carps is not met with in *Barbus dubius.* The average diameter of the unfertilised egg is 1.6 mm. After fertilisation the perivitelline space expands a little. The average diameter of the fertilised egg is now 2.4 mm. (Photo 2). In the other Major Carps, however, the perivitelline space swells to 4 to 5 times against 1.7 mm (photo 3) of space. The fertilised egg of *Barbus dubius* is heavy, demersal and immediately sinks to the bottom, unlike the fertilised eggs of other carps which get drifted and consequently get caught in spawn nets. This heavy character of the fertilised egg has a bearing on the distribution of the species to sub-mountainous zones only.

Twelve hours after fertilisation the headfold gets differentiated (Fig. 11). Twenty-four hours old egg clearly brings out the tailfold and the embryo at this stage is 0.30 c.m. Now the headfold and tailfold become clearly differentiated from the yolk. The rudiments of the eye appear but there is no pigmentation anywhere (36 hours old-Fig. 12). Seventy two hours after fertilisation the embryo hatches out and the uncouth alevins with the big yolk sac, are long (Fig. 13). The yolk sac has become long and tubular with a swollen rounded anterior portion and a tubular posterior portion constricted in two places. The median finfold has appeared and the larval tail is flat and transparent. The rudiments of vertebral column are formed. The eyes develop slight pigmentation. With the formation of the pericardium, the larval blood circulation commences. The hatchling is 4 m.m. when 96 hours old. The eyes develop pigmentation. The embryonic vertebral column is distinct and the rudiments of the brain have been differentiated. The swollen anterior portion of the yolk remains unchanged, while the tubular portion shrinks considerably. The pericardium has been differentiated into a larger anterior and a narrow posterior chamber. The rudiment of the stomach has been formed.

On the fifth day after hatching the larvae are long, the mouth has opened and the larval stomach and anus are differentiated clearly. A portion of the yolk sac still remains unabsorbed. The gill slits have opened out and there is an active flapping of the opercle. The paired pectorals are active now. The eyes are deeply pigmented as also the dorsal portion of the head. There are scattered rounded pigments on either side of the mid-dorsal line as far as the peduncle.

By the tenth day, the hatchlings are long, a distinct caudal blotch has appeared tending to be more prominent in the lower half. The dimunitive dorsal fin as also the paired fins and the anal fin are well formed. The yolk is completely absorbed. Barbels have not yet appeared.

When larvae are 1.3 to 1.4 cm. long rudiments of scales appear along with barbels. The fry now move out in batches yet restricting themselves to the eddies and shallow areas of the spawning belt. By about February, the entire shallow area near the spawning beds is full of these fry in various stages of growth. It is possible to make large scale collections of pure fry from these niche (Fig. 14).

The position of the dorsal before the ventrals distinguishes the fry from uneconomic minnows of the genus, *Barilius Danio* and *Rasbora* found in the same niche. The smaller barbels, *Barbus* (*puntius*)*Sarana*(Hamil) *and Barbus filamentosus* do not occur mixed with the fry of *Barbus dubius* and even if found they develop a dorsal blotch and prominent scales earlier. In *Barbus dubius* there is practically no pigmentation till it is 1 c.m. long. The fry of 1 to 1.5 c.m. show a lateral band against a clear back ground and by 1.4 to 1.5 the characteristic dorsal blotch bent downwards develops. In the field collection however along with *Barbus dubius Barbus hexagonolepis* occurs. Size for size the latter is darker and the blotch is spread equally above and below (Fig. 15).

## Discussion.

*Barbus dubius* is a fish distributed in the upper reaches of the Cauvery and Bhavani in the sub-mountainous area. These areas are akin to the Greyling zone, Barbel Zone (Marcel Huet 1959) of Western European streams. Many of the multi-purpose reservoirs are constructed in these zones and hence the study of the biology of the fish *Barbus dubius* in the new reservoirs is of immediate importance from the point of view of its growth and repopulation. While Barbus dubius has become an established Fishery in Bhavanisagar and Krishnarajasagar its disappearance from Mettur Reservoir is answered by a study of the breeding habits.

1. The fishes grow to a good size in the reservoirs as was recorded from Mettur originally and now from Bhavanisagar. They grow to 250 m.ms. in the I year, to 360 m.m. II year to 440 mms. III year 520 mms. IV year 570 mms. V year 610 mms. VI year, and 670 mm. VII year. The corresponding growth in weight from second year onwards is 455 gms. 975 gms., 1,527 gms., 2,335 gms., 3,017 gms, and 3,505 gms.

2. They feed mainly on the benthic chironomid larvae, frèsh water oligochaetes, insects and nymphs at depths from 2 to 10 meters. They also feed on the plankton of the reservoir.

3. The fish breed once in a year extending from October to December. The fecundity spawning and development has been worked from field collections and by artificial stripping.

4. There is a distinct short spawning migration from November onwards towards the top waters of the not very big hill streams. The eggs are laid in shallow gravelly areas by the side of rapids and pools and the fish return to the reservoir after the spawning. Both the upward and return migration have been intercepted by drift nets for analysis.

5. The eggs are heavy with little perivitelline space unlike carps and hence they do not get drifted with the floods. The fry hatch out in large number in the spawning belt and get washed down when they are 3 to 5 cms. long. Thus the reservoir below the spawning belt gets successfully repopulated. In the case of Mettur Reservoir, the Hoganaikal falls connecting the top river becomes a natural barrier during October to December bacause it is insurmountable. The migration was checked which accounted for the disappearance in Mettur. Similarly in Amaravathy Reservoir situated in Coimbatore, the top water is intercepted by the Duvanam falls where oozing breeders congregate in large numbers from December. By February, the gonads get atrophied as the fish are prevented from spawning. The only repopulation in this case is stocking, the top water immediately above with breeders and allowing the fry to get drifted down. There is always an assured chance of repopulation of *Barbus dubius* in all reservoirs with even a small hill stream like top water run where free access to spawners is assured.

6. The fishes are caught in synthetic yarn Rangoon nets and best catches are recorded after the spawning season The nets are laid to advantage in the 5 meters to15 metres belt of the reservoir around the top waters where they congregate after spawning.

7. The conservation programme must aim at completely closing for any type of fishing, the top waters for a distance 7 to 8 miles which are the favourite spawning grounds.

For Commercial fishing in the reservoir, drift net with mesh of 6 cm. fully stretched and above may be allowed. Then the fish three year and below will not be caught and breeder stocks will be maintained to get a fair chance of spawning once.

The fish is recommended for stocking any major reservoir in the sub-mountainous area provided there is a suitable river stretch above with no barrier preventing the upward migration.

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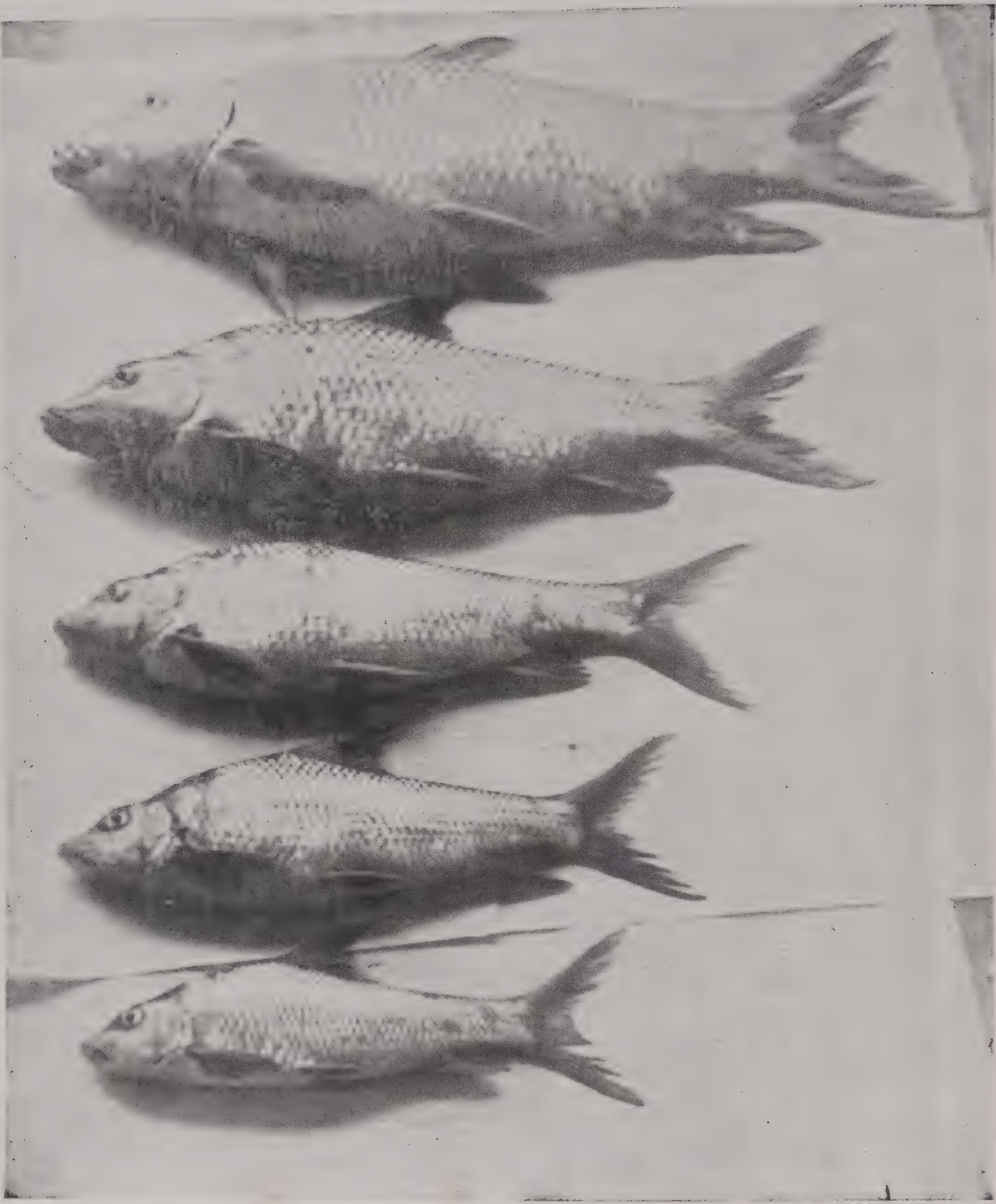


Photo 1—*Barbus dubius*—Five-year classes fishery from Bhavanisagar landing.

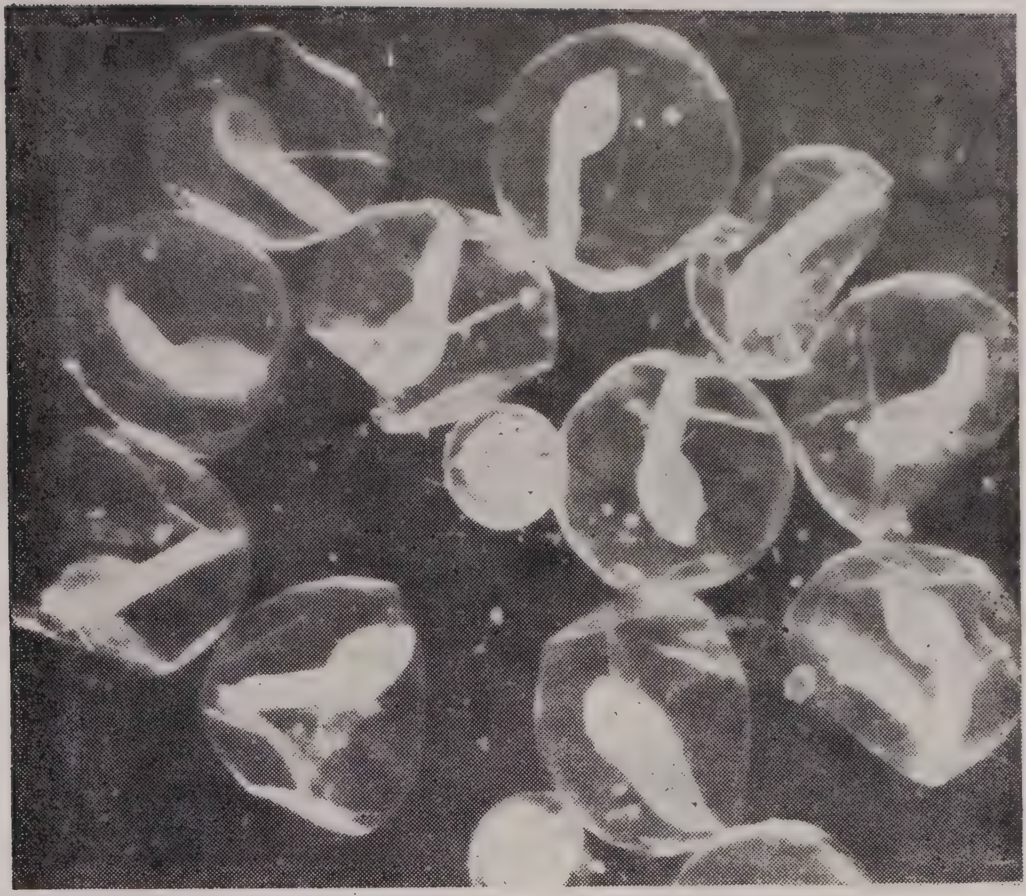


Photo 2—Fertilised egg of *L. Rohita* from induced spawning

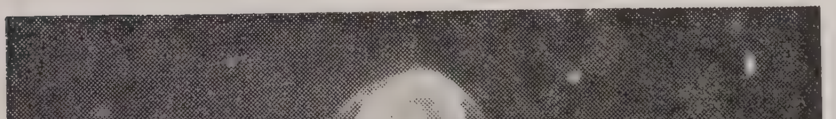


Photo 3—Fertilised egg of *B. dubius* in various stages of development

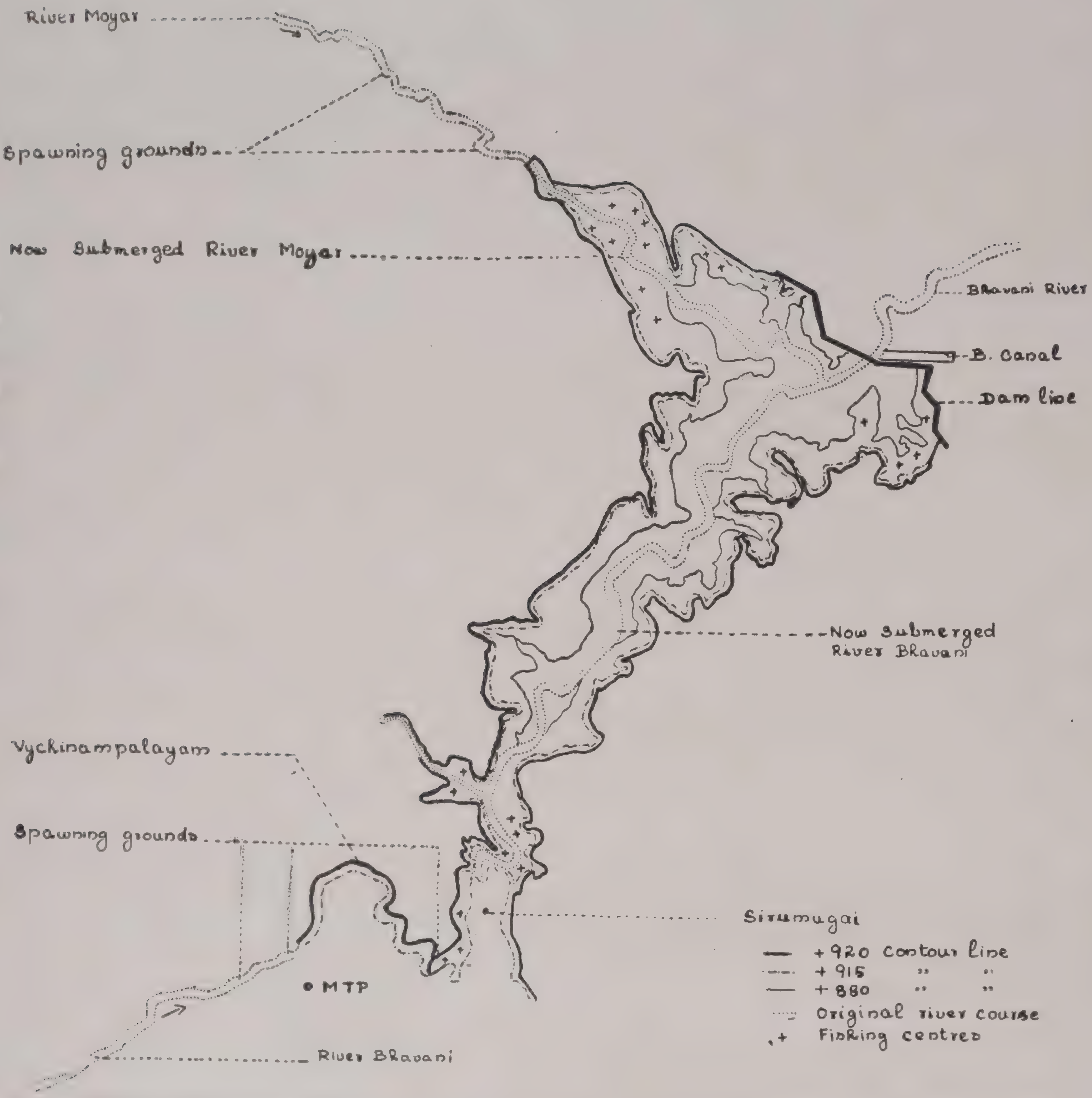


Fig. 1—Bhavani Sagar Reservoir Showing contourline, Fishing centres and Spawning beds of Barbus dubius.

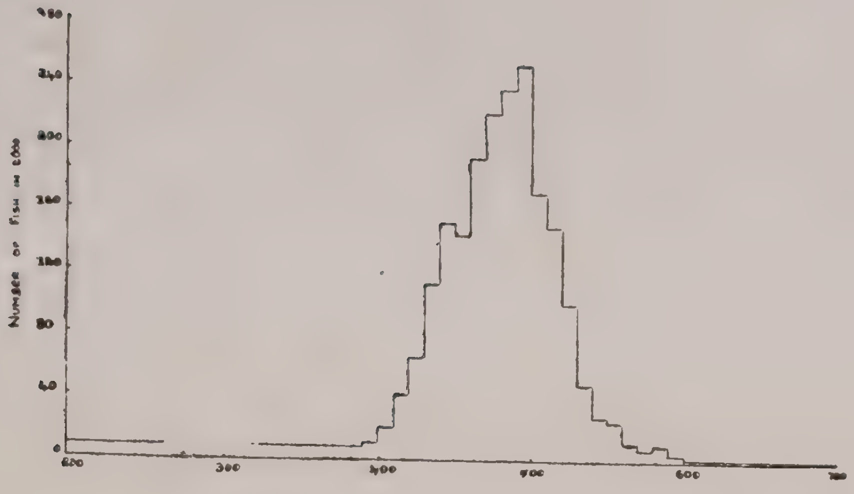


Fig. 2—Total Length m.m.

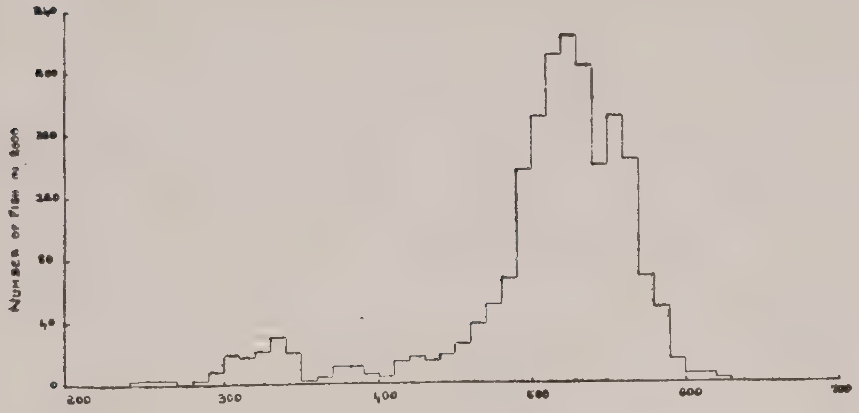


Fig. 3—Total Length m.m.

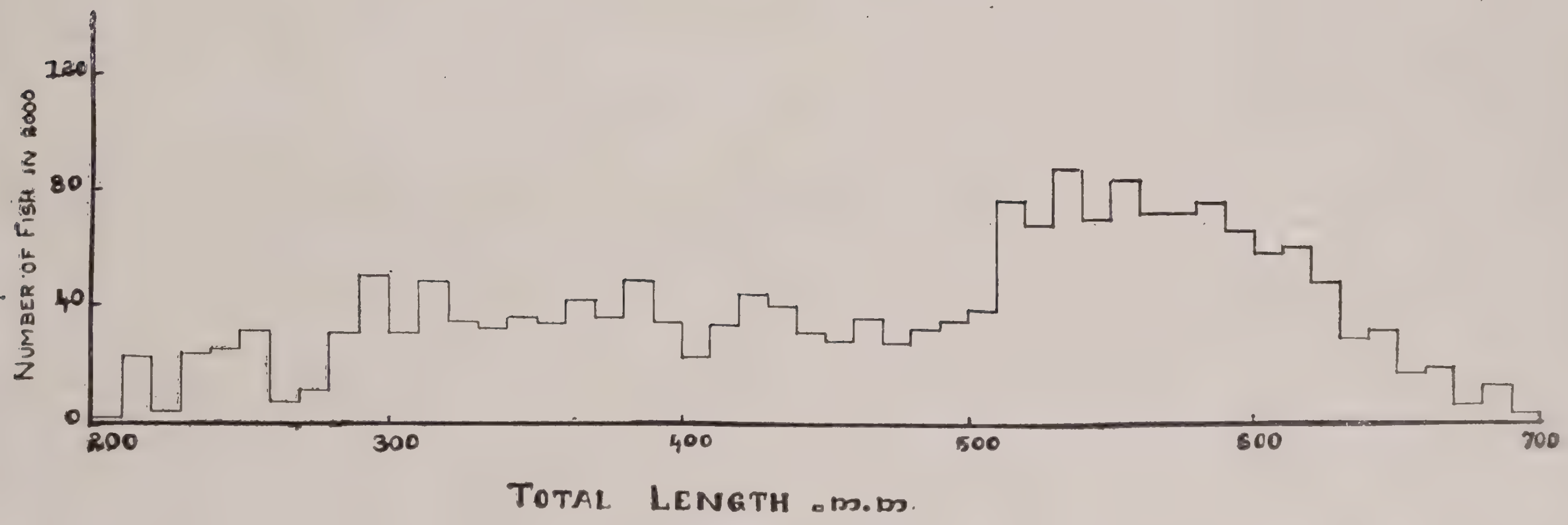
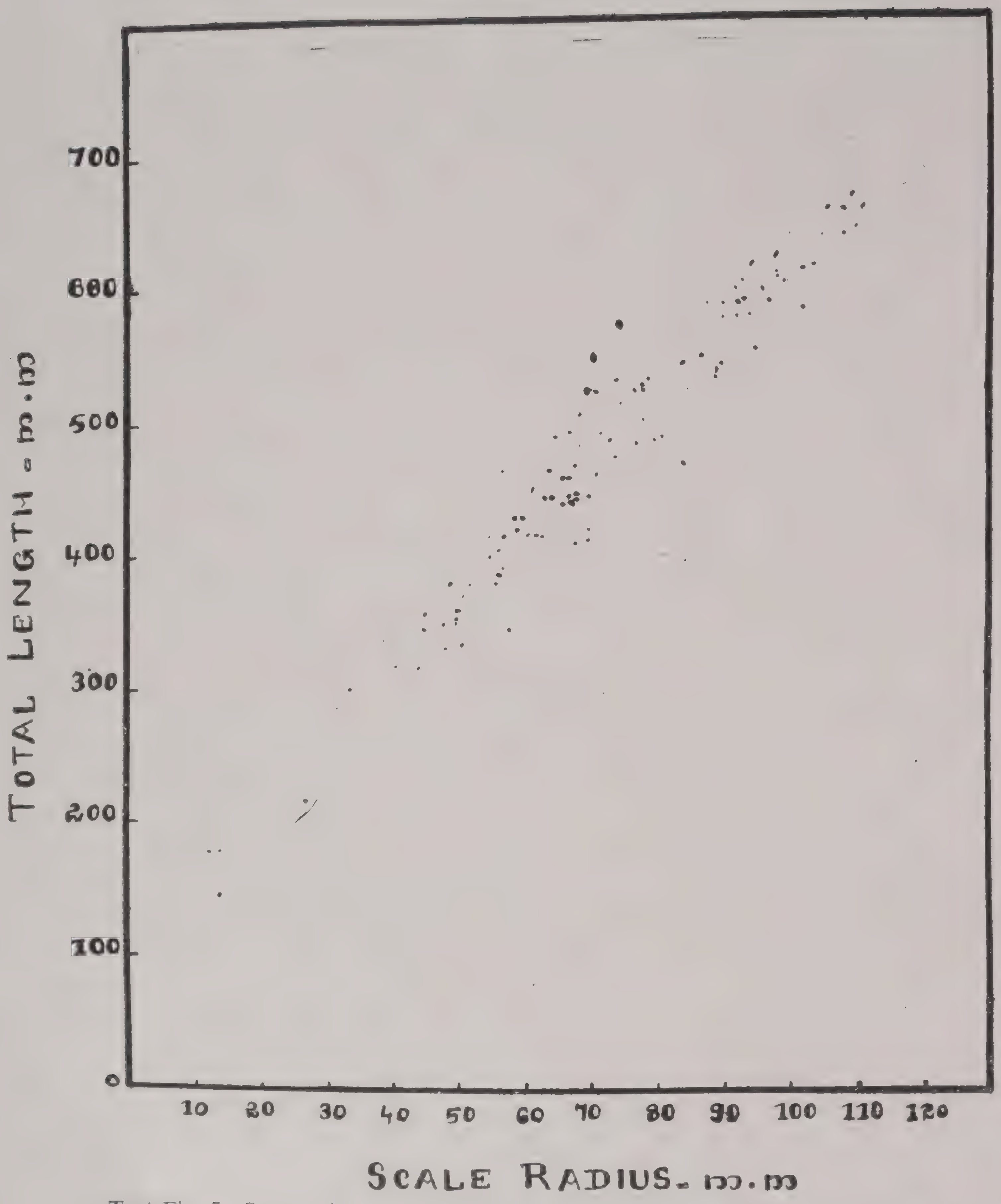


Fig. 4—Total Length m.m.



Text Fig. 5—Scattered diagram of total length and radius of scale in *B. dubious.*

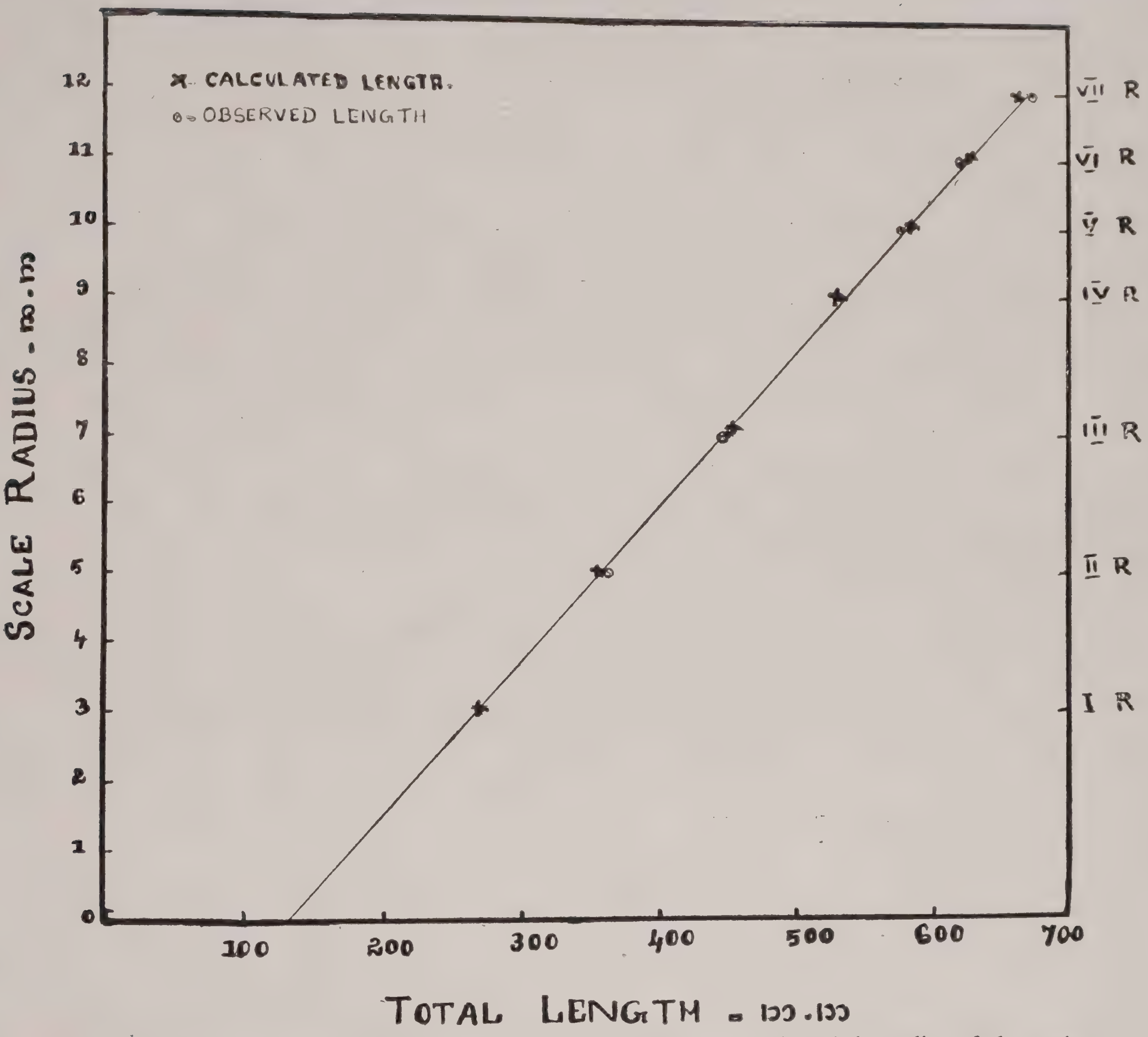


Fig. 6.—Graph representing observed mean length calculated length and the radius of the scale.

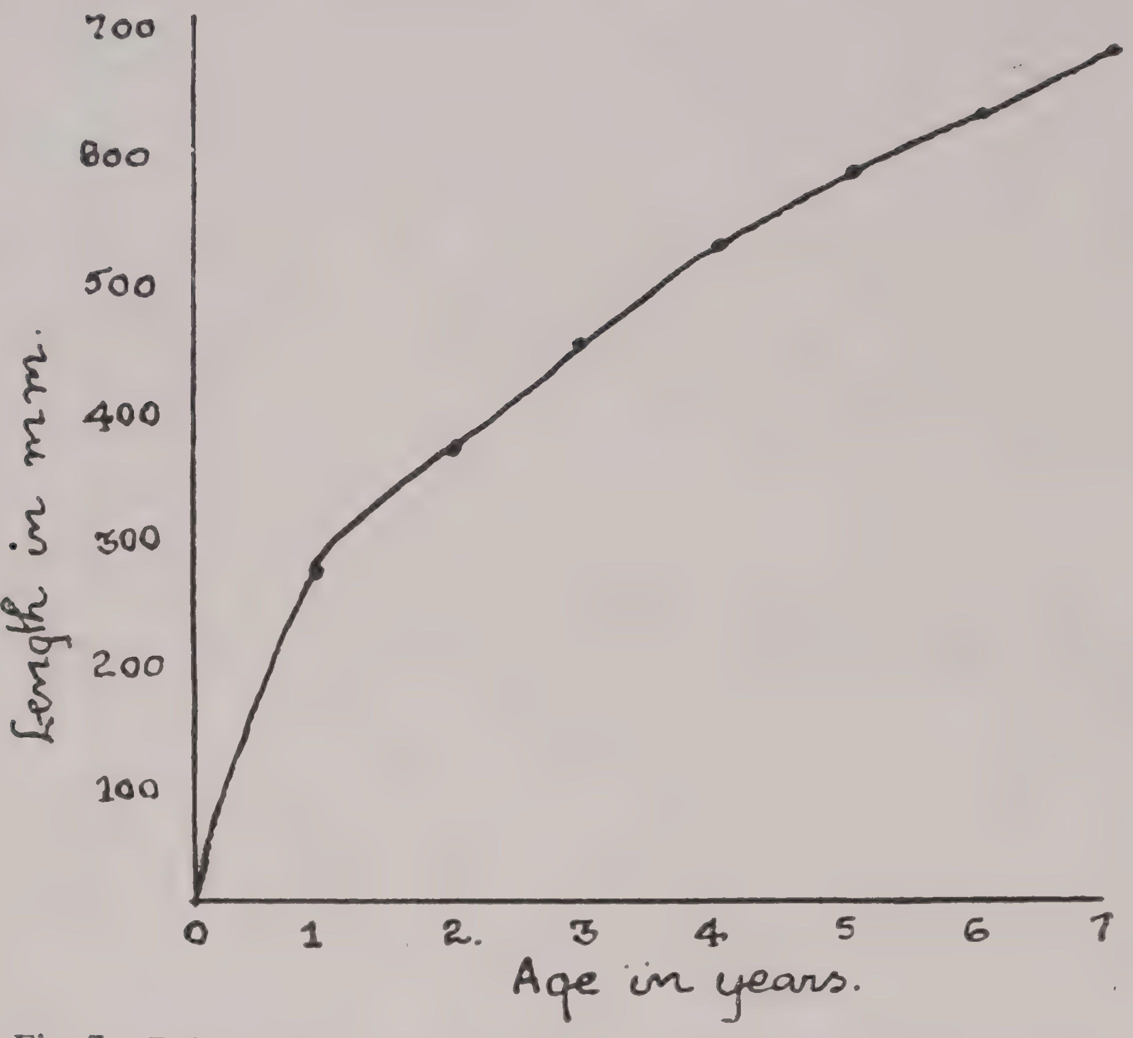


Fig. 7.—Relationship between age in years by scale reading and calculated length.

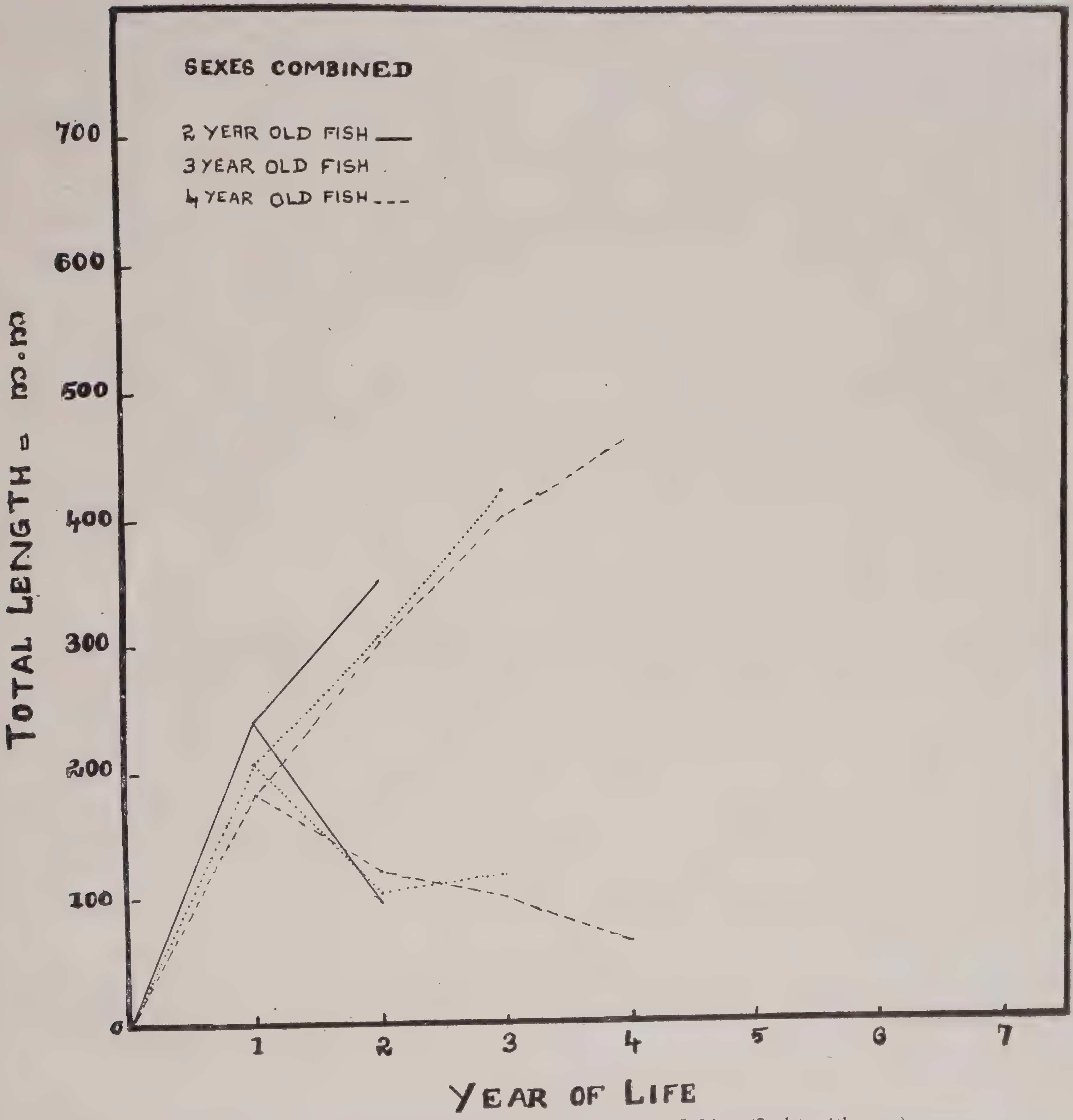


Fig. 7 (a)—Growth in length and increment in *B. dubius* (2nd to 4th year)

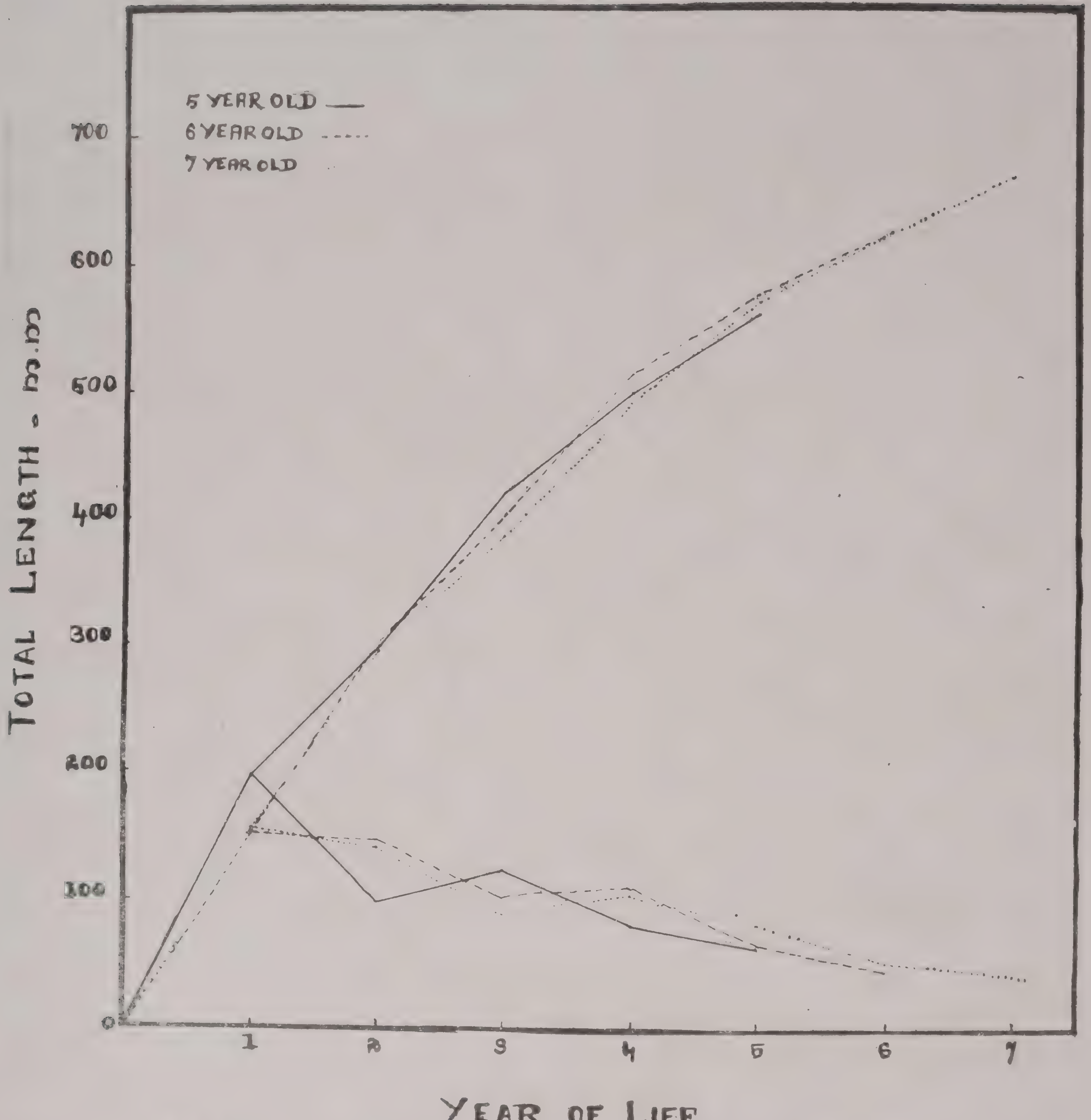


Fig. 7 (b)—Growth in length and increment in *B. dubius* (5th to 7th year).

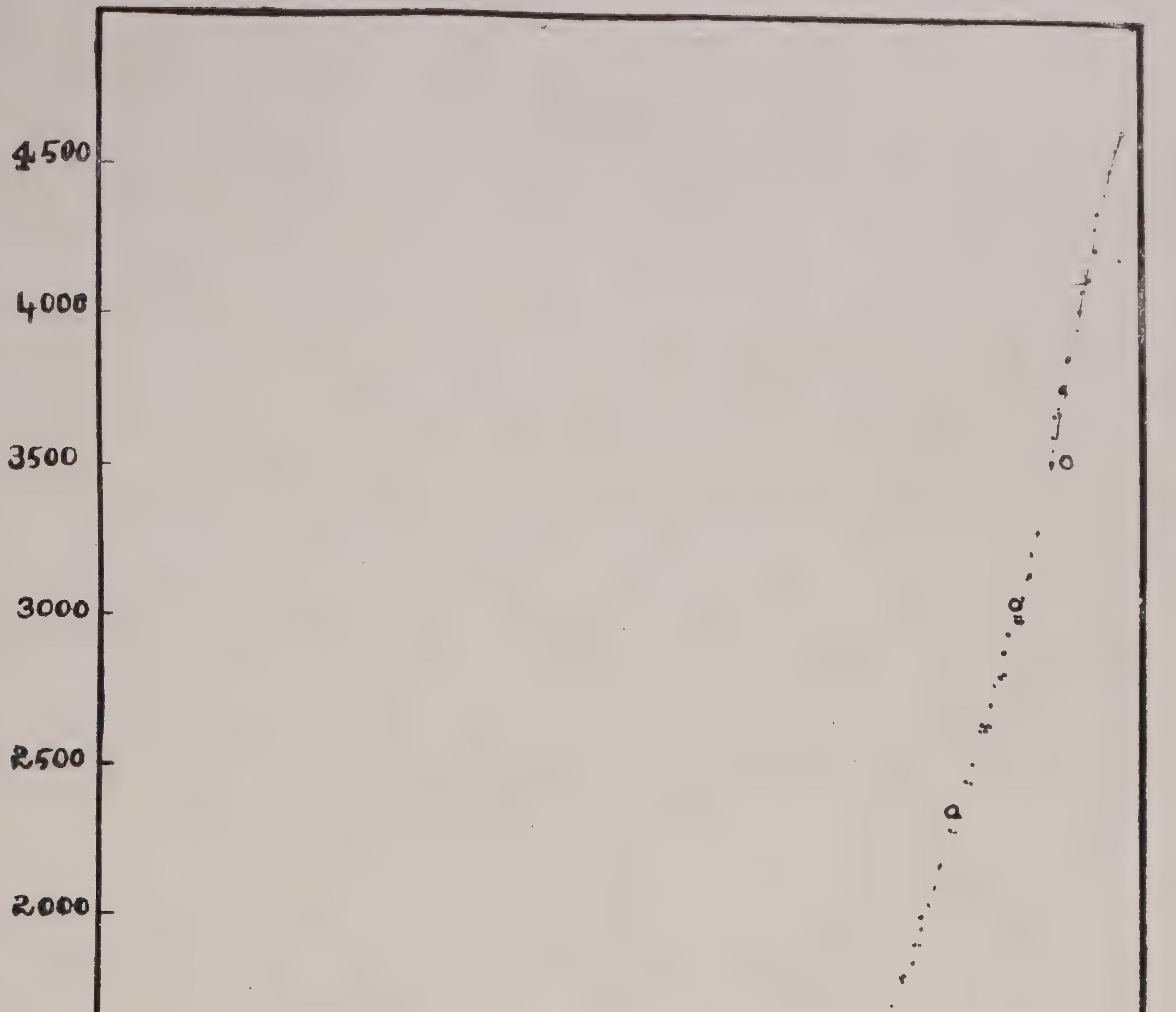


Fig. 8 –Scattered diagram of weight on length in *B. dubius*. (O—denotes calculated weight using the formula $W = Cln$.)

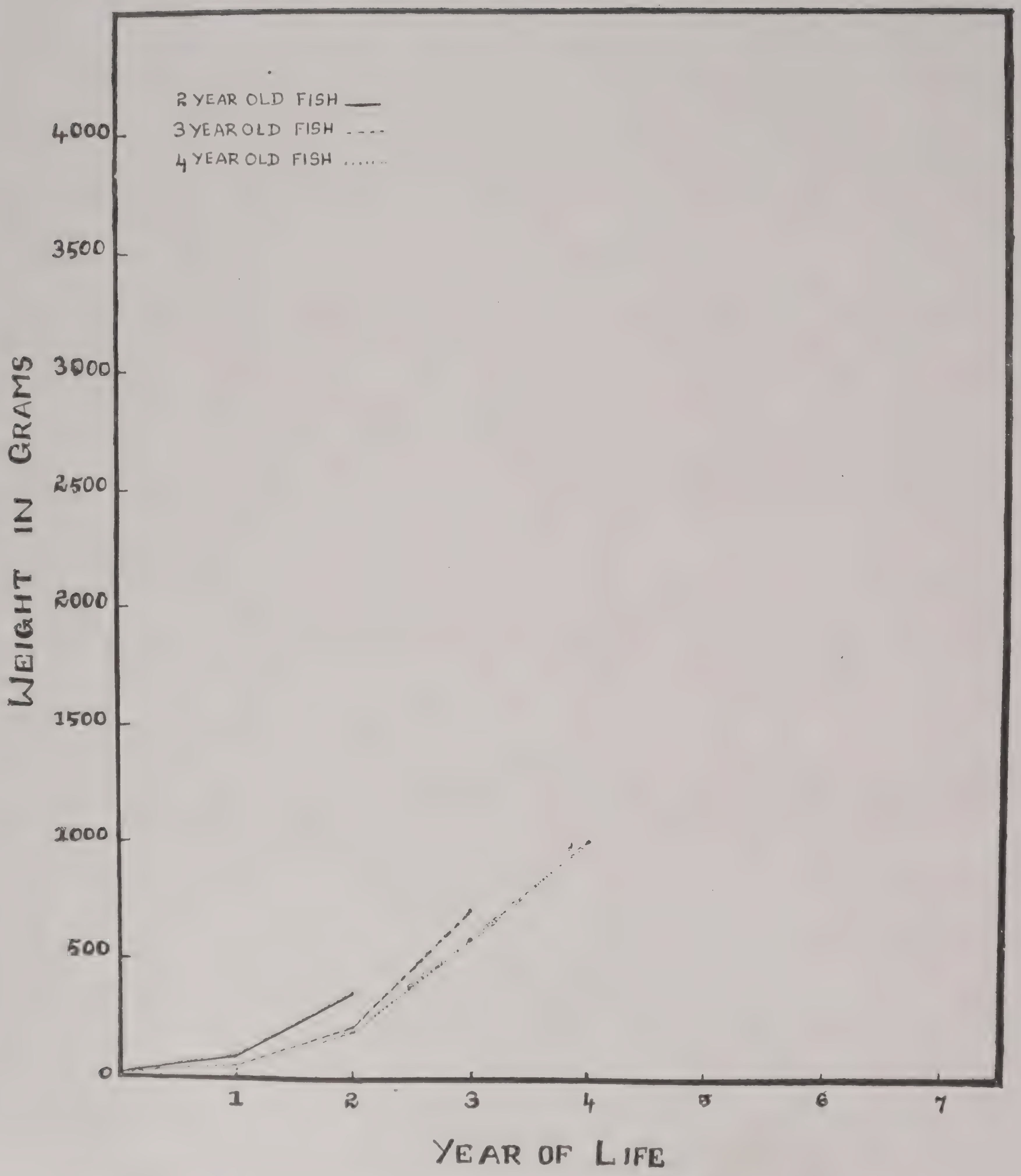


Fig. 9.--Calculated growth in weight at the end of each year of *B. dubius* (2nd, 3rd and 4th year)

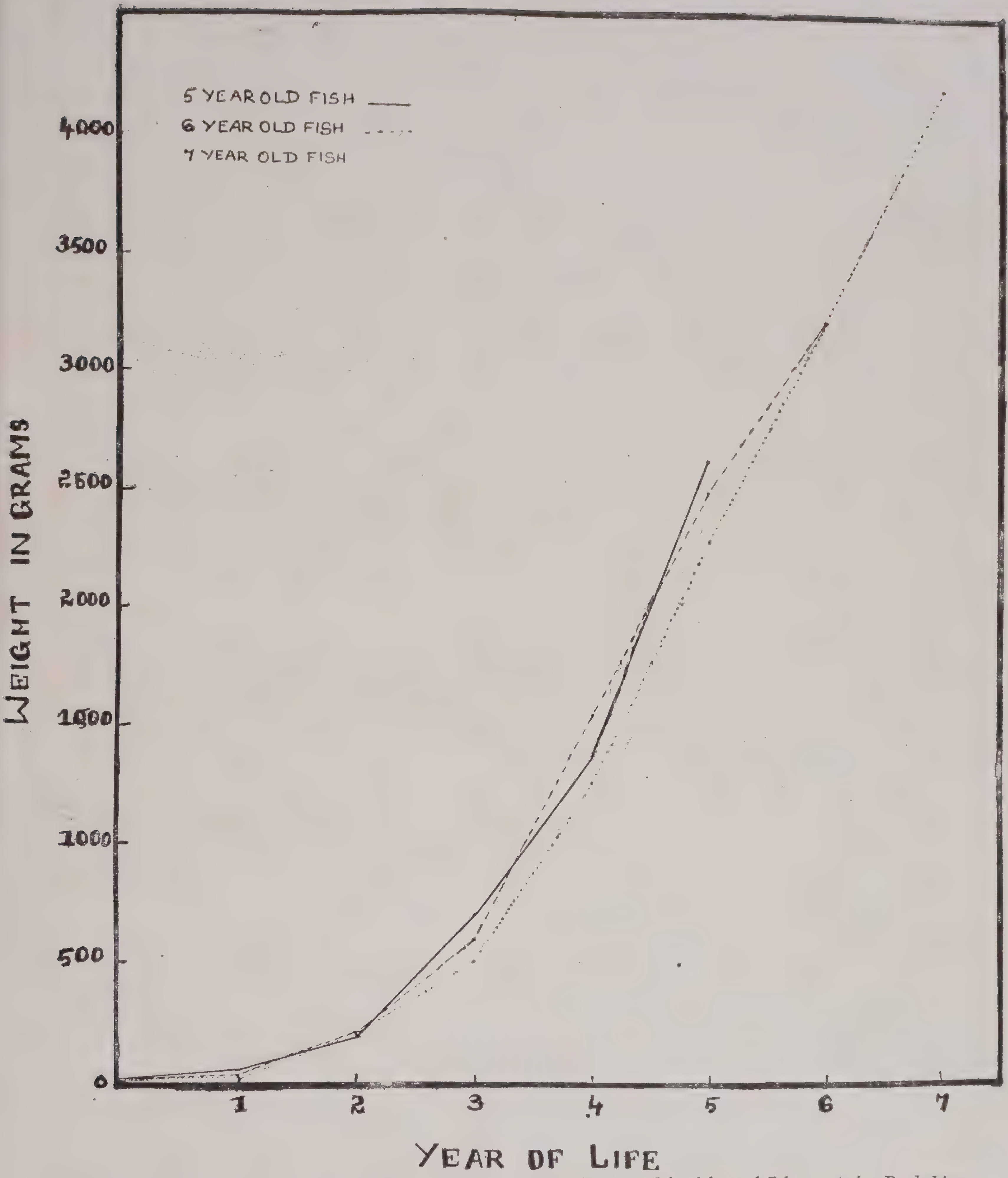


Fig. 10.—Calculated growth in weight at the end of each year (5th, 6th and 7th year) in *B. dubius.*

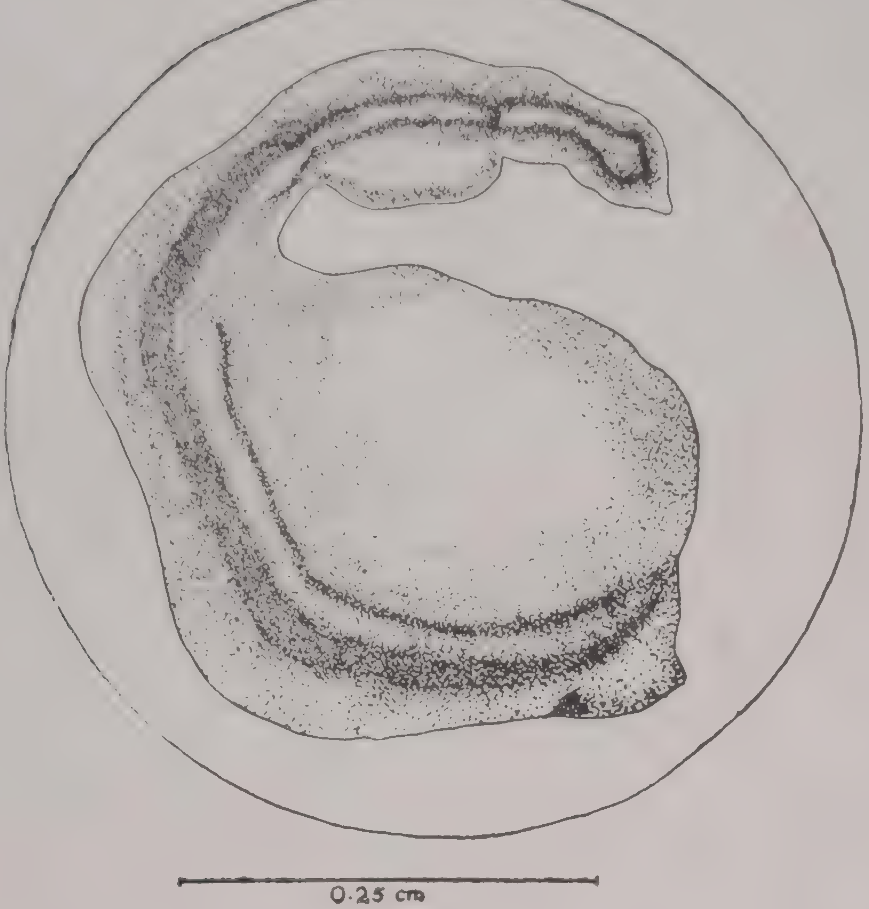


FIG. 11—Fertilized egg of Barbus dubius 18—hours old.

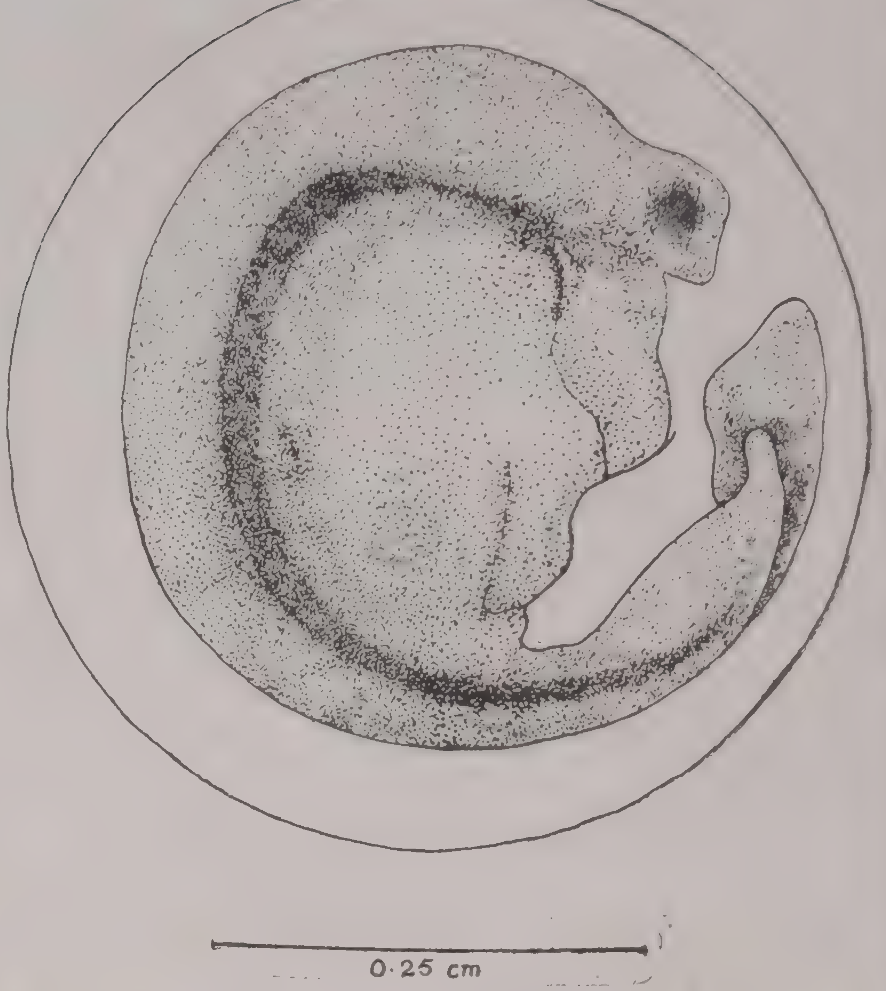


FIG. 12—Fertilized egg of Barbus dubius 36—hours old.

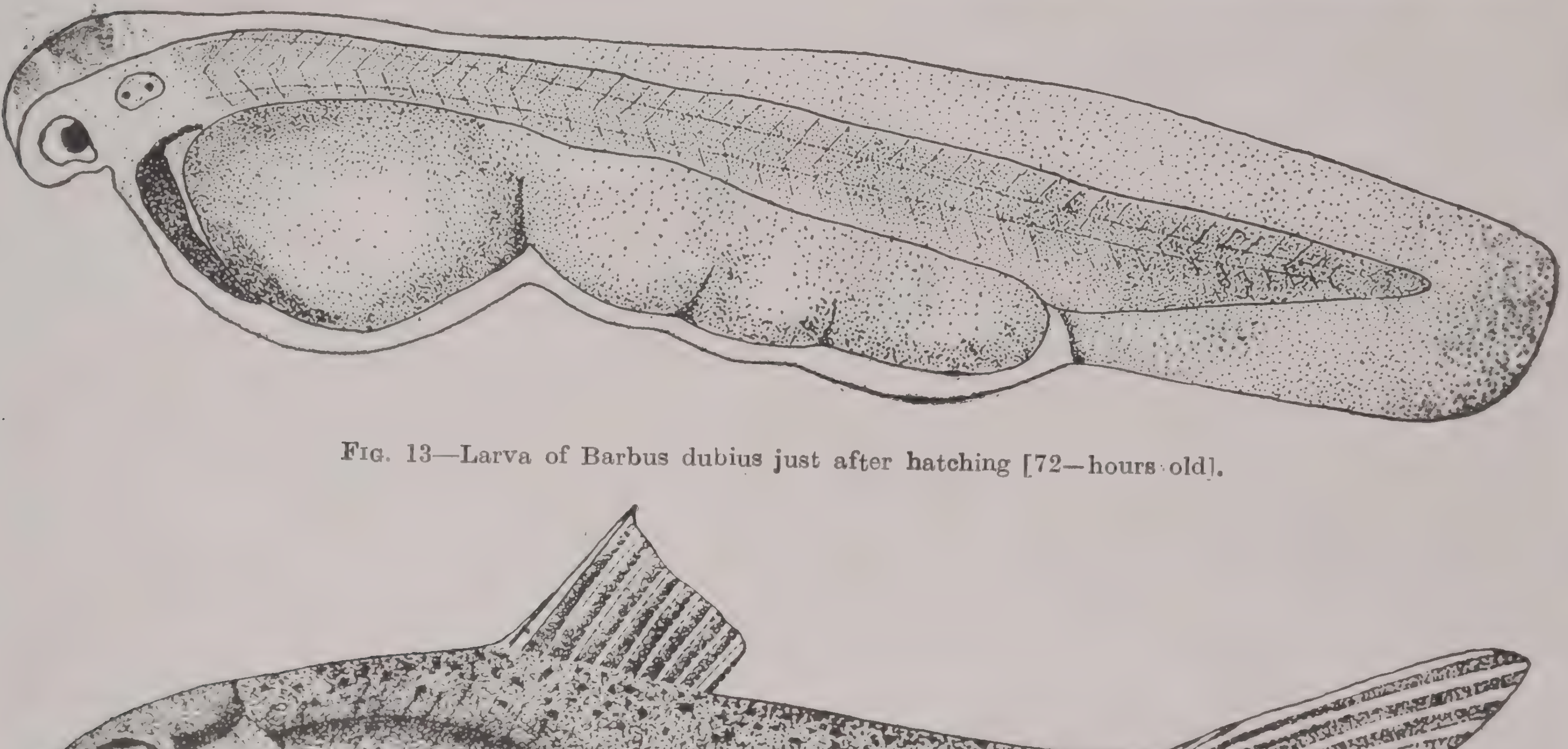


FIG. 13—Larva of Barbus dubius just after hatching [72—hours old].

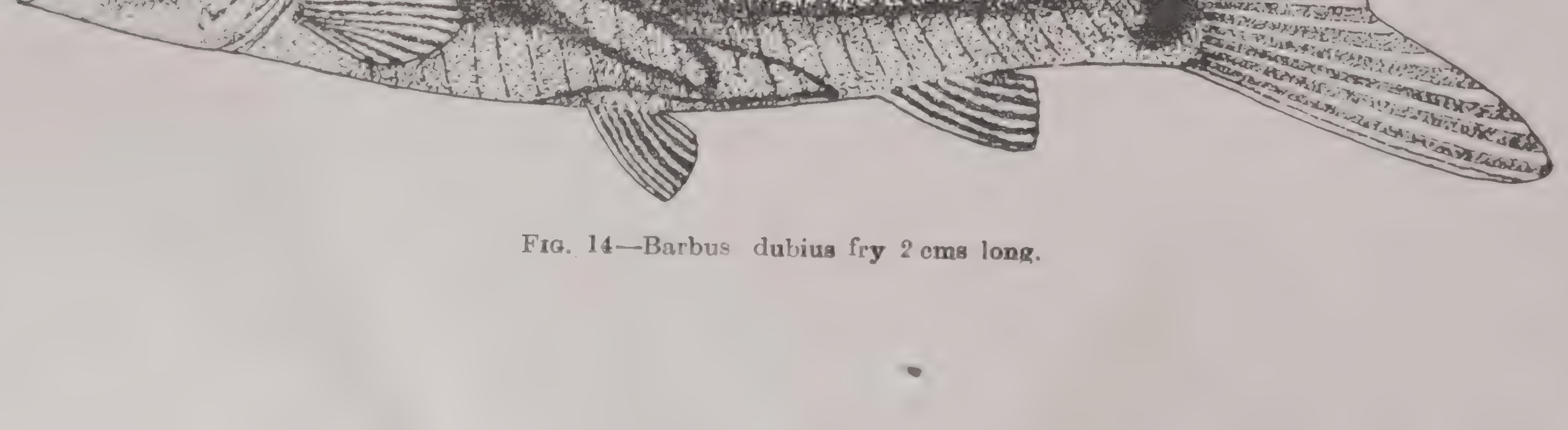


FIG. 14—Barbus dubius fry 2 cms long.

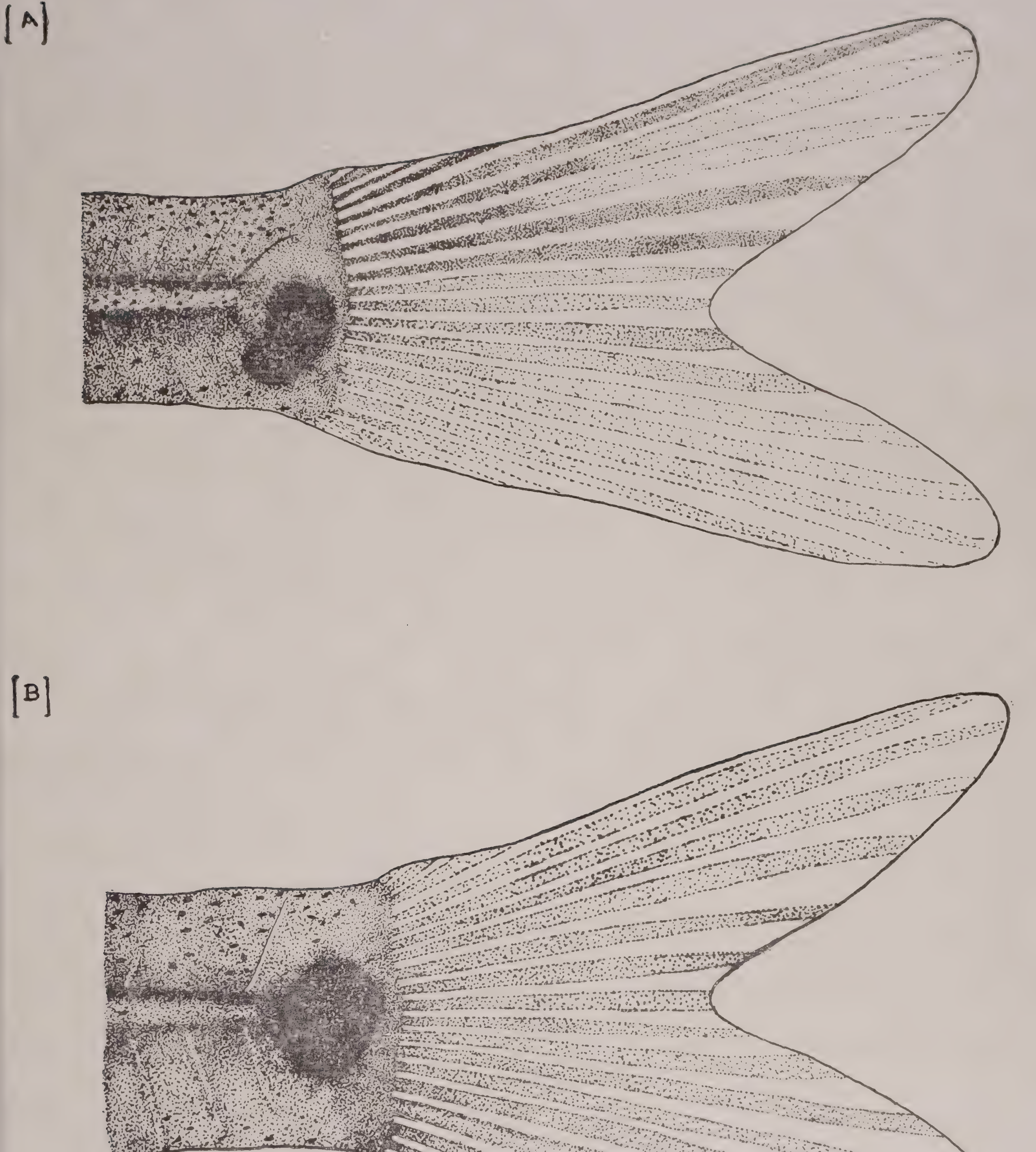


Fig. 15—Caudal peduncle of 0 cms. long fry of [A] Barbus dubius and [B] Barbus hexagonolepis.

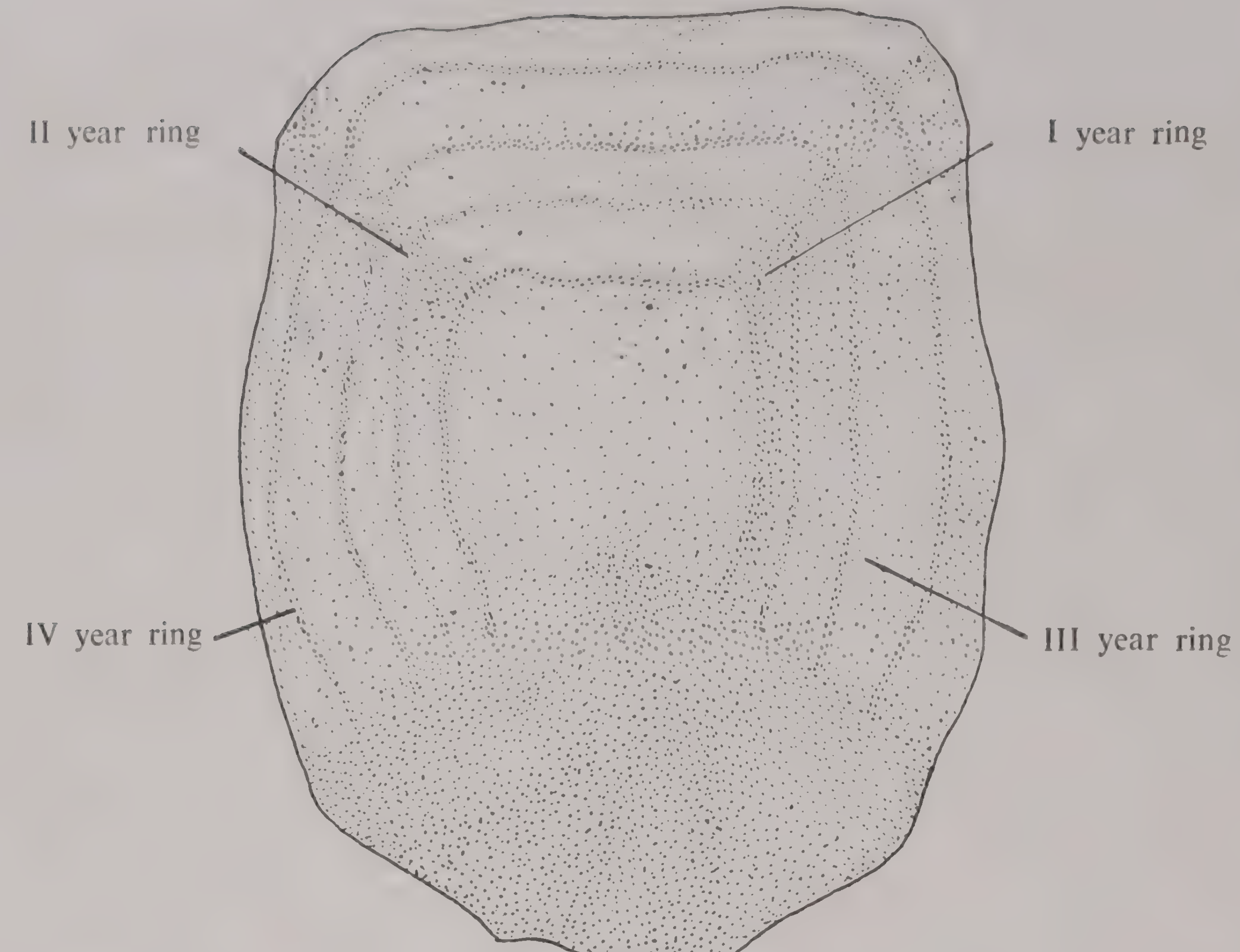
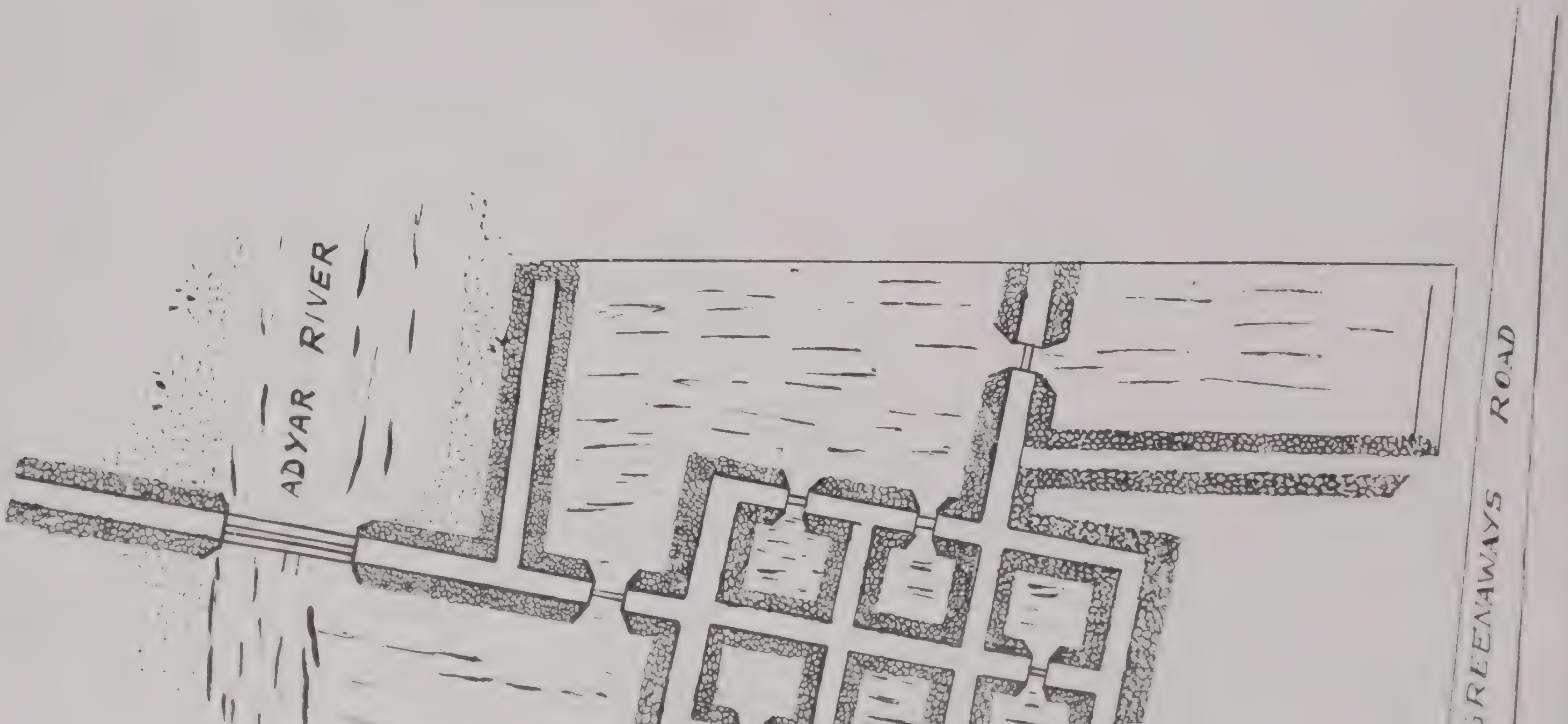


Fig. 16—An×6 camera pucida drawing of a scale of *B. dubius*, 4 years old.



ESTUARINE FISH FARM, ADYAR, MADRAS.

# STUDIES ON THE AGE AND GROWTH OF THE KEERIMEEN CHALAI SARDINELLA SIRM

BY

KUMARI A. G. GNANAMEKALAI, MARINE FISHERIES BIOLOGICAL STATION, TUTICORIN.

## Introduction.

In the economy of the fishing villages of the East Coast of Madras State, there is probably no fishery of greater importance than that of the Sardines, locally called *Chalai*. Though studies regarding the fisheries and biology of *Sardinella fimbriata* and *S. Gibbosa* have been conducted by workers like Bapat (1955), Chacko (1946, 1949, 1950, 1956 and 1959), Chacko and Palani (1959), Chacko and Rajendran (1956), Devanesan (1932), Devanesan and Chidambaram (1953), Panikkar (1949) and Sekharan (1955), not much attention has been paid to *Sardinella sirm*, except for a few observation by Chacko and collaborators (1956 and 1959) and John (1951). This paper gives an account of the investigations on the age and growth of *Sardinella sirm* which contributes to a valuable fishery in the Gulf of Mannar off Tuticorin, the season extending for about six months from October to March.

## Material and Methods.

The specimens of *Sardinella sirm* used in these investigations were collected by the random sampling method from the commercial catches of fish from the off-shore fishing grounds off Tuticorin Coast. The chief gear employed for the capture of these sardines was the *Kola-Valai*, a type of drift net composed of six sections, each of 120 feet length (26 metres) and 40 feet (12 metres) breadth and of half-inch (72 mm.) mesh from knot to knot. Altogether 170 samples totalling 14,500 specimens were collected from January 1957 to March 1961. The specimens were measured at the landing centres itself in the most fresh condition. Specialised methods were not employed for obtaining juveniles and smaller fishes, below 130 mm. size except in 1958 to 1959 season when a *Chalai-Valai* a small meshed drift net was used. Total length of the fish was taken from the tip of the snout to the end of the longest caudal ray.

The minimum and maximum size recorded from the normal commercial catches was 125 mm. and 25 mm. This range was divided into ten millimetre groups and their frequency was represented as in Figures 1, 2, 3, 4, and 5. This showed the percentage distribution of the size supply in the monthly samples. Where the totals were too small to be representative of the population the figures have been left out in the reckoning as having no samples for the purpose of length-frequency studies. Percentages have been tabulated in preference to total numbers in each size-group to facilitate comparison of data for different months as the total differed from month to month. Size sampling and calculations of means were made for the samples individually and then compilations done by monthly totalling. Recalculation of the different values on this basis resulted in the increases of the value of larger samples analysed and in the month-to-month values being more reliably comparable than the sample-to-sample values. Any possible variations in the monthly totals due to uncontrollable sampling errors were also considerably reduced.

## Size composition of Commercial Catches.

1. *January to April* 1957.—There were two modes in January, one at 140 mm. and the other at 170 mm. appearing as two separate stocks. In February, there was a new mode at 130 mm. probably representing another stock for the year. The mode at 170 mm. might represent a growth of 30 mm. of the 140 mm. group and merging with the 170 mm. group of the previous month that did not show any conspicuous growth. This might be due to rapid growth resulting in the fish spawning towards the end of February. In March there was a mode at 180 mm. denoting a growth of 10 mm. The mode at 210 mm. might probably show spawning growth of the 170 mm. group that either showed a steady growth in February or was not represented during that month. The growth which thus seemed to have occurred in one or two months might coincide with spawning activity from the latter part of February to the end of March. The non-representation of the 130 mm. group in March was due to the increased percentage composition of 150 to 170 mm. groups merging with the total stock indicating growth of the fish. In April, the season came to a close with landings on a few days only and as such the mode at 180 mm. represented the same stock met within the previous month, while the 210 mm. group might have been fished out. Assuming that spawning occurred in the latter half of the season, there might have been probably a spawning in the early half of the season. This was confirmed by observations made during the succeeding seasons. Likewise it is probable that there was a spawning in each of the three months to result in four spawnings in one year, two met with in the fishery season along Tuticorin Coast and the other two in the off-season.

2. 1957–58 *Season*.—The fish appeared in September 1957, and the fishery extended to March 1958. In September, there had been two modes on at 170 mm. that formed the major fishery and the other at 210 mm. The former was evidently the main stock for that year's fishery and from the recruits from the spawning in the early half of 1956–57 season. The latter group might be an older group of the previous year. In October, the second peak

at 210 mm. was no longer visible resulting in a unimodal curve with a peak at 180 mm. Assuming that the population had been the same throughout the forward movement of the mode by 10 mm. indicated clearly the growth that occurred during that period. In the next month, there were three modes. One was at 170 mm. denoting fresh entrants into the fishery. These might be the off-springs of the second spawning that occurred in February 1957 in the latter half of the 1956–57 season. This also showed that more than one spawning occur in one season confirming the average of one spawn in three months. The second mode is at 190 mm. due to the 10 mm. growth of 180 mm. group. The third mode at 220 mm. illustrating the growth by 10 mm. of the 210 mm. group of September. The non-representation of these in October might be due to the lesser landings and fewer number of samples analysed. In December, which was the peak season for the fishery, the three modes had advanced by a few millimetres indicating the growth of all the three size-groups. The 170 mm. group showed an advancement by 10 mm. represented by the mode at 180 mm. The 190 mm. group has grown to 220 mm. group. The 220 group showed a growth of 30 mm. 20 mm. reaching 240 mm. This greater advancement was indicative of the spawning of the 190 mm. and 220 mm. group. This was the first spawn of the season. During January 1958, the 24 mm. mode of December had disappeared. The 180 mm. group had advanced by 10 mm. and represented at 190 mm. constituting the main fishery, while the 220 mm. group had not attained much conspicuous growth. In February, the mode at 190 mm. was predominantly indicating the main stock of the fishery which in addition to the mode might probably be fresh recruitment, indicative of two other spawnings that might have occurred during the off-season. The 220 mm. group was not to be observed, having been fished out, in all probability. The mode at 210 mm. might represent rapid growth of the 190 mm. group of January indicating the second spawning during the season. In March, a new mode was seen at 180 mm. which might probably be the spawning growth of the 140 mm. group. It can be safely presumed that the first maturation of the fish, took place nearly at the 140 mm. size. Hence, the age of the fish of 140 mm. was one year. Growth was not conspicuous with the 190 mm. group also, that had not attained any mode, but it could be understood that growth had taken place, from the greater percentage of the 190 mm. and 220 mm. groups, in the previous month. The 210 mm. mode showed the same crisis with addition in the bigger size-groups, denoting inconspicuous but steady growth.

As confirmed, it was seen that each three months enclosed one spawning of the fish as such, a season consisting of six month's showed two spawnings. There might be two more spawnings for the fish species during the other half year which is the off-season. Its fishing at Tuticorin as spawning occurred in November and February during the fishing season at Tuticorin, was suggestive that the third and fourth spawning might be in May and in August during the off-season when the fish had moved into deeper waters. With this in consideration, it was clear that fresh recruitment with the commercial catches occurred in September 1957 (170 mm.), November 1957 (170mm.) and in February 1958 (140 mm. and 190 mm.). These four stocks might be out of the four spawnings of the previous year. As could easily be recognised, the 170 mm. set of September 1957 might be of the May 1956 spawning. Likewise, the 170 mm. set of November 1957, the 190 mm. and 140 mm. of February 1958 might be of the spawning in August 1956, November 1956 and February 1957. On the whole in the 1957–58 season, the 170 mm. group of September 1957 had grown over 50 mm. to reach 220 mm. in December. The 170 mm. set of November 1957 showed advancement of 40 mm. reaching 210 mm. in February 1958. The 210 mm. groups of November 1957 showed an increment of 30 mm. to reach the 240 mm. maximum size in December 1957. The average growth rate is thus about 12 mm. in a month. But this increased to 20—30 during the month immediately preceding spawning actually.

3. 1958–59 *Season.*—The fishery commenced only in November, when three modes at 100 mm., 140 mm. and 170 mm. were seen to occur. The 170 mm. size-group comprised the main bulk of the fishery and probably was from the spawning of August 1957. Correspondingly, the 140 mm. and 100 mm. groups might be of November 1957 and February 1958 spawnings. It was interesting to find that the intermediate size-groups of 110 mm. and 120 mm. were not at all represented in the catches. During December, there were again 4 modes. The 110 mm. mode indicated a growth of 10 mm. of the 100 mm. fish. The mode at 130 mm. might be a fresh group, probably of the November-December 1957 spawning that was not represented in the previous month. The 160 mm. mode might be due to the 20 mm. growth of the 140 mm. group and similarly the 190 mm. mode showing the growth of 20 mm. of the 170 mm. groups. The growth increment of 20 mm. put in by the 140 mm. and 170 mm. might forecast a spawning at this time which is the assessed first spawning period of the season. In January, there was a new mode at 90 mm. of juveniles. These along with the 110 mm. to 130 mm. fish were collected separately by means of '*Chala Valai*' of nearly 8 mm. knot to knot. This 90 mm. group might probably be a population of the August 1958 spawning having completed only six months. The mode at 120 mm. represented growth of 10 mm. of the 110 mm. group of December. There was also a mode at 170 mm. which might denote a growth of 10 mm. of the 160 mm. group. The 130 mm. group was not represented and this might be due to a probable migratory move of some groups of the year classes to deeper waters, when in January the fishery came to a drop for a few days. In February, the main bulk of the commercial landings comprised only 170 mm. sized fish. This might be the same group of January growing steadily without showing any conspicuous mode. The growth of the 130 mm. group of December was not likewise conspicuous perhaps due to its migration, to be non-represented as in the last month. However, growth curve below 170 mm. indicated more representatives of 150 and 160 mm. sizes. This might prove the rapid growth of the 130 mm. group and its merger with the bulk of 170 mm. group.

As the fishery for this season was poor, enough samples for length-frequency studies could not be had in March.

However, for the whole season, there were three size-groups. The 100 mm. group of November showed a growth of 20 mm. by January, a period of about two months, showing steady growth before completion of one year and attainment of maturity. The 130 mm. group of December showed a growth of 40 mm. to reach 170 mm. in February, a period of three months. The 140 mm. group had put in a growth increment of 30 mm. in three months.

4. 1959–60 *Season.*—During this season sufficient data on the studies could not be collected due to administrative reasons and lack of personnel and consequently the studies could not be carried out.

5. 1960–61 *Season.*—The fishery commenced in October 1960, with the 180 mm. and 220 mm. size-groups. In the next month of November two modes occurred one at 180 mm. and another at 150 mm. representing the stocks of the August and November 1959 spawning. The 210 mm. mode obviously showed the rapid growth of 180 mm. group by 30 mm. to forecast the first spawning of the season, while the 220 mm. group of October was not represented. This denoted that the older group had been fished out. In December, the mode at 180 mm. stood steady, while the 150 mm. group that might have attained maturity and a growth of 30 mm. merged with the 180 mm. group. The bigger groups of 20 mm. and above were not represented. During January, a new mode was seen at 170 mm. which might probably be the stock of the November 1959 spawning. There was also a mode at 210 mm., indicating growth of the 180 mm. group by 30 mm. This intense growth obviously signified an imminent spawning. In the next two months, the new set of 170 mm. group showed a steady growth of 10 mm. so as to form the mainstay of the fishery towards the close of the season. The 210 mm. group showed an advancement of 10 mm. to reach a size of 220 mm. The non-representation of the other groups might be due to the fewer numbers in the random samples that could be obtained.

In this season, the 180 mm. group only predominated but the 150 mm. group of November showed a growth increment of 30 mm. in two months up to December 1960. Further growth was not conspicuous to produce any mode, but growth was noted by the larger percentages of bigger groups above 180 mm. extending up to 230 mm. The 180 mm. group had put in a growth of 40 mm. reaching 220 mm. size in three months. The speedy advancement in size of the 150 mm. and 180 mm. groups in November and January respectively indicate spawning and it was evident also that there were two spawnings in the fishery season of six months.

## Growth rate.

The studies on the various size-groups, though showing seasonal fluctuations throw considerable light on the growth of the fish. In the 1956–57 half-season, the 140 mm. group appearing in January 1957 showed a growth rate of 40 mm. in three months. More rapid growth occurred in February 1957. The 170 mm. group of January 1957 had grown over 40 mm. in three months. Spawning growth occurred in February-March.

The 1957–58 season proved the growth of 140 mm., 170 mm. and 210 mm. groups. The 140 mm. group appearing in February reached 180 mm. in March and their intense growth denoting spawning might also show the first maturity of the fish. One group of 170 mm. appearing in September had put in a growth of 50 mm. within December in four months, indicating spawning growth in December. Another set of 170 mm. appearing in November had grown through 40 mm. to reach 210 mm. in February a period of four months. Greater growth denoting spawning occurred in February. The group had stood steady for the first two months. The 210 mm. group appearing in September had a growth increment of 30 mm. to reach 240 mm. in December, when intense growth is also seen and as such December and March might be considered as the two spawning months for the season.

In 1958–59 season, 100 mm. group appearing in November over 120 mm. in two months by January. The 130 mm. group appearing in December was not represented conspicuously in the other months, and might be said to grow steadily and slowly, being a juvenile group. The 140 mm. group appearing in November showed a sharp growth in December and reached 170 mm. in January. This growth rate was very satisfactory.

During the 1960–61 season, the 150 mm. entering in November showed a sudden growth of 30 mm. in December and thereafter did not show any conspicuous mode. The 180 mm. group of October advanced rapidly in November to reach 210 mm., growth increment being 30 mm. in two months. Another set of 180 mm. entering into the fishery in November showed a steady growth till December and grew up suddenly by 30 mm. from January to February to reach 220 mm. The growth was 40 mm. in four months. Thus November and February appeared to be the two spawning months for this season.

## Inference and Conclusions.

From the foregoing studies the following inference and conclusions are made :—

(1) *Sardinella Sirm* attains maturity when 140–150 mm. in total length.

(2) The growth in length is steady till 210 mm. when the fish spawns for the second time.

(3) The fish reaches senescence and maximum size of 240–250 mm. in nearly 1½ years.

(4) Bigger specimens up to 300 mm. in length are rarely seen during the off-season.

(5) The fishery season from October to March is short and is about one-fourth of the probable life span of the fish.

(6) As these occur in more than one fishery season within the full life period, there is a period of successive spawning.

(7) There is one spawning period every three months in November-December and February-March during the fishery period and in May-June and August-September during the off-season.

(8) The main spawning periods in the life of the fish are when 140–150 mm., 170–180 mm. and 120–210 mm. in length.

(9) Juveniles below 140 mm. in length and older ones above 250 mm. in length are not obtained in the commercial catches.

(10) Rate of growth averages 10–12 mm. a month.

(11) There is a rapid growth of about 20–30 mm. in the month prior to spawning.

## Acknowledgment.

I am indebted to Sri P. I. Chacko, Assistant Director of Fisheries (Information and Marine Biology), for suggesting the problem and for the guidance and encouragement given during the course of the investigations.

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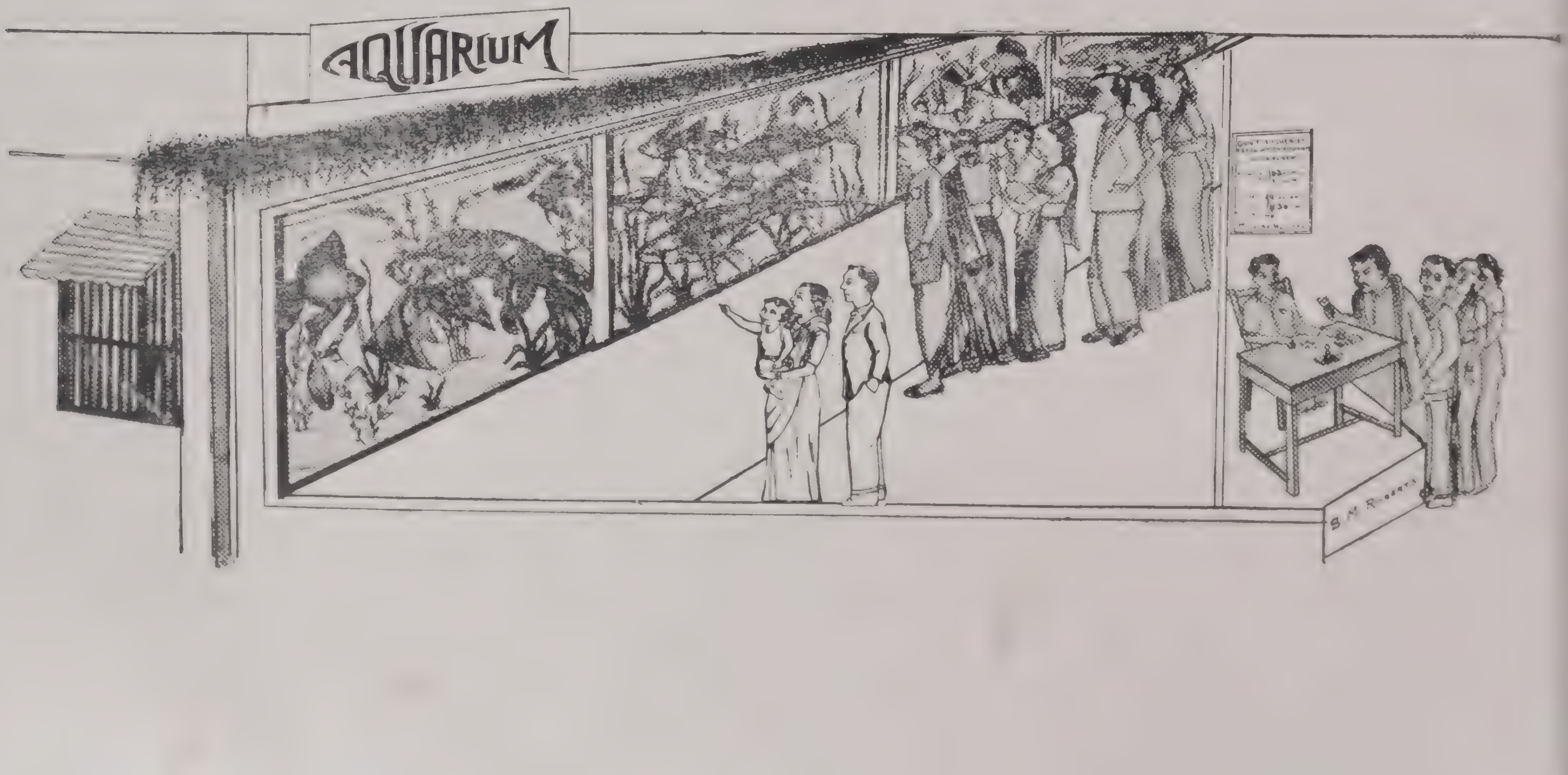

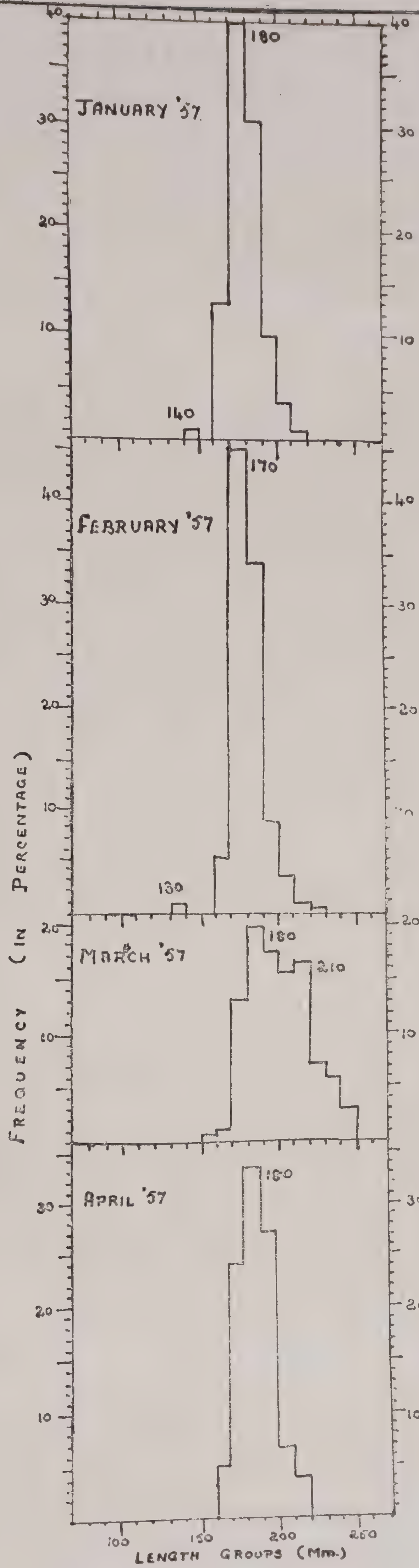

Fig. 1. Monthly Length frequency distribution of Sardinella sirm during 1956-57.

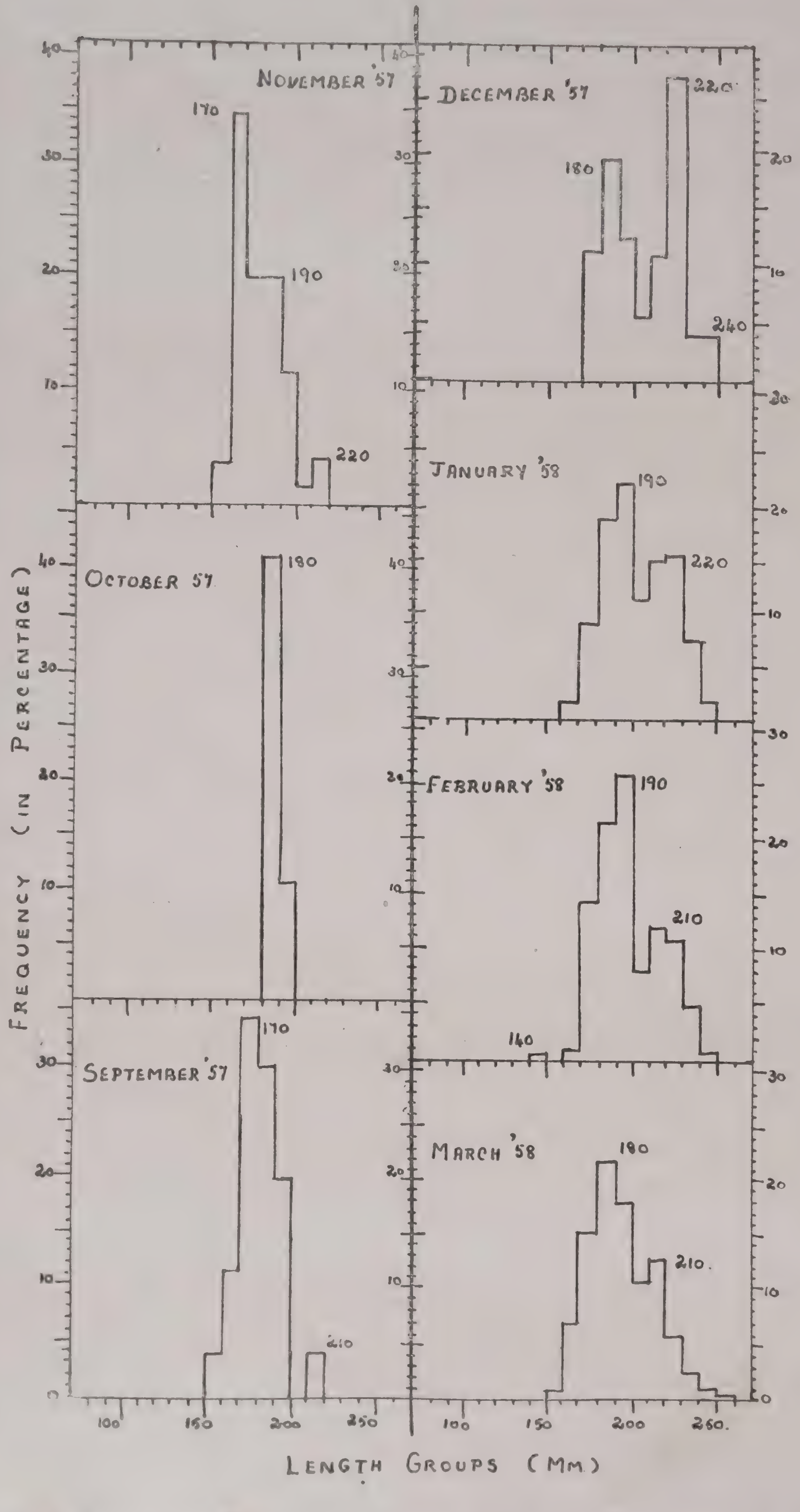

Fig 2. Monthly length frequency distribution of Sardinella sirm during 1957-'58

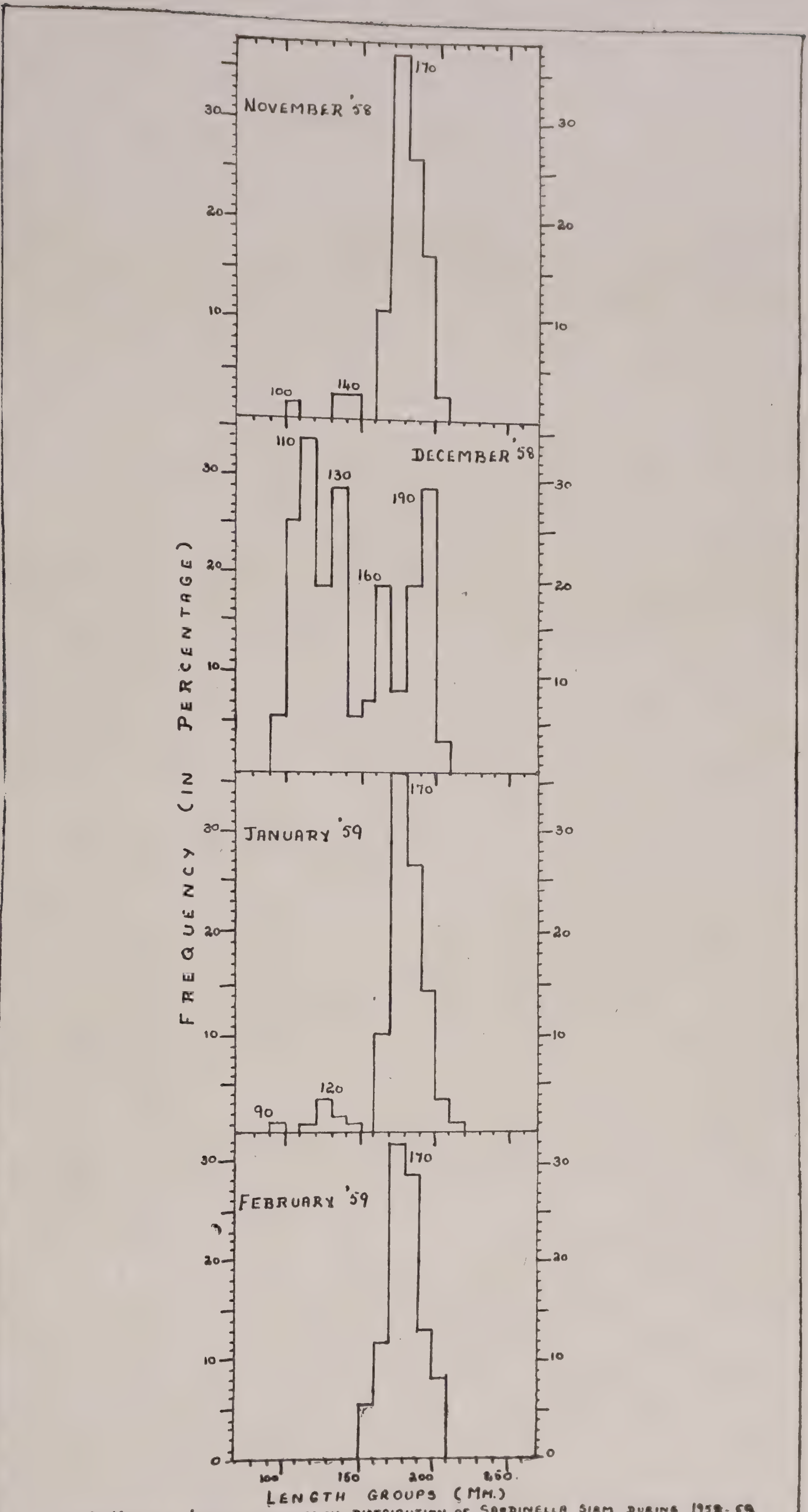

FIG. 3. MONTHLY LENGTH FREQUENCY DISTRIBUTION OF SARDINELLA SIAM DURING 1958-59

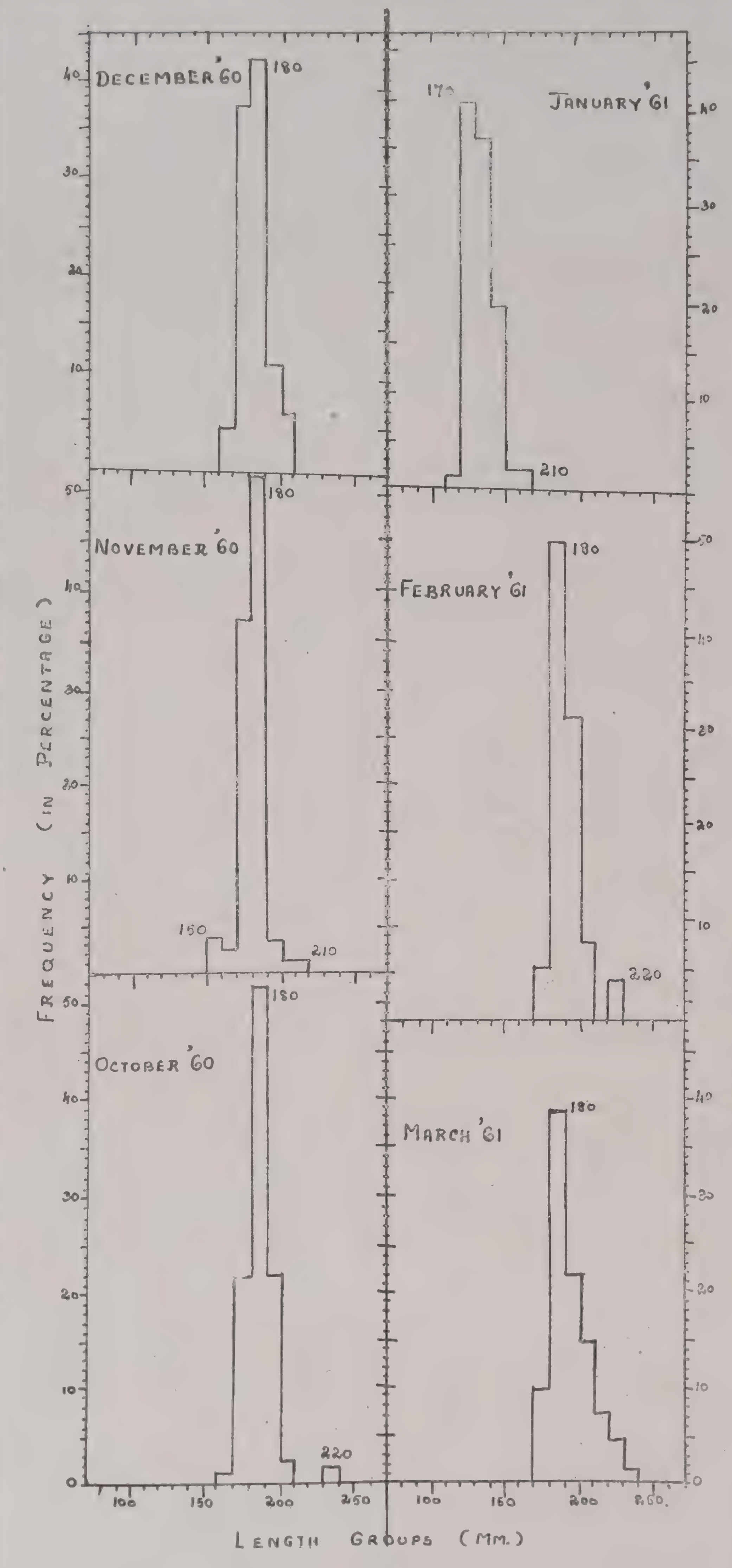

FIG 4 MONTHLY LENGTH FREQUENCY DISTRIBUTION OF SARDINELLA SIRM DURING 1960-'61

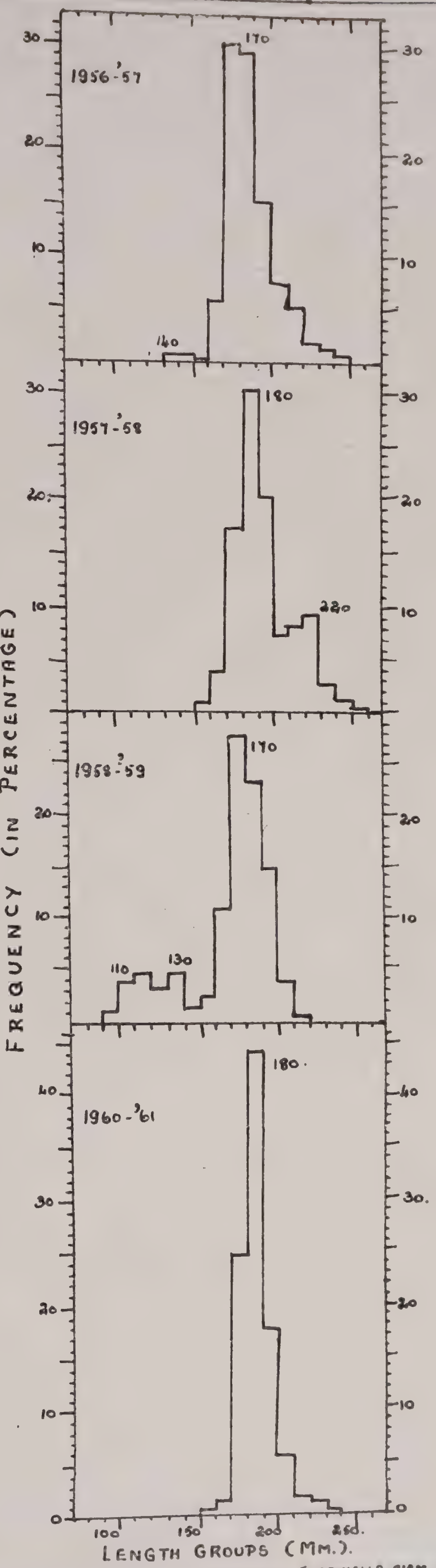

FIG. 5. ANNUAL LENGTH FREQUENCY DISTRIBUTION OF SARDINELLA SIAM DURING 1956-57; 57-58; 58-59 AND 1960-'61.

# FOOD AND FEEDING HABITS OF FISHES OF THE PERIYAR LAKE

BY

Srimathi J. G. ABRAHAM, Public Health Fish Officer, Chetpet, Madras.

**Introduction.**

The Periyar Reservoir constructed across the Periyar River in about 1890, utilises a portion of the waters of this river for irrigating lands in the Madurai, Melur and Nilakottai taluks of the Madurai district.

The 150-feet high dam has created an extensive lake. Its water are diverted eastwards through a mile long tunnel and are led into Suri'iyar which again joins the Vaigai river flowing through Madura and Ramanathapuram districts before its outfall in the Bay of Bengal. The Periyar waters irrigate 143,000 acres of land. The lake is surrounded by thick and evergreen forests on all sides and is replete with wild game. It has been declared a game sanctuary.

A survey of the fish fauna of the Periyar lake was conducted in March and July 1954. Collections were made from different sections of the lake and the inflowing streams by employing cast nets and velon-screen, dragnets in shallow areas and kondivalai and Rangoon nets in the deeper portions.

*List of fishes.*—The following kinds of fish were collected from the lake during the survey :—

(1) *Barbus curmuca*
(2) *Barbus micropogon*
(3) *Barbus tor*
(4) *Callichrous pabda*
(5) *Discognathus lampta*
(6) *Saccobranchus fossilis*
(7) *Ambassis ranga*
(8) *Barbus aurelius*
(9) *Barbus melanampyx*
(10) *Barilius bakeri*
(11) *Botia historensis*
(12) *Etroplus maculatus*
(13) *Aplocheilus lineatus*
(14) *Lepidocephalichthys thermalis*
(15) *Macropodus cupanus* and
(16) *Rasbora daniconius*

*Food and Feeding Habits.*—This was investigated as detailed below :—

(1) *Barbus curmuca*—

| | |
|---|---|
| Size range .. .. .. | 16·5—37·5 cms. |
| Length of gut .. .. | 26·5—74 cms. |
| Number of guts examined | 17 |
| Number of empty guts .. | 1 |
| weight of gut contents .. | 4–10 gms. |

*Gut analysis*—

Rotifers, *Cypris*, Daphnids, *Navicula*, filamentous algae, macro vegetation, Graminae seeds, blades of grass bamboo leaf bits and seeds.

The guts are nearly double the length of the fishes. Of the seven guts examined, three showed, zoo-plankton. The other four showed grass blades, Graminae seeds, bamboo leaves and seeds which show that, *B. curmuca* feeds mostly on macro vegetation like grass, bamboo leaves and fruits. They were also reported to be found feeding along the banks of the reservoir on grass in shallow waters.

(2) *Barbus micropogon*—

| | |
|---|---|
| Size range .. .. | 34–35 cm. |
| Number of guts examined | 4 |
| Length of stomach .. | 16·5–45 cm. |
| Weight of gut contents .. | 50–100 gm. |
| Vol. of gut contents .. | 48–95 cc. |

*Gut analysis*—

| | |
|---|---|
| Large black ants. | Jumblum nuts each of 19 grammes weight +1·1 cc. vol. |
| Beetles ; | Caesalpinea leaves. |
| Wings of aquatic insects ; | Bamboo leaves. |
| Rotifers ; | other Macro vegetation. |
| *Cyclops* ; | Germinated seeds. |

*Feeding habits.*—The stomach is well differentiated from the gut and is nearly half the length of that of the gut and in 2–4 cms. in diameter. All the guts examined showed 50 per cent of large black ants, water beetles and hundreds of wings of aquatic insect. The number of wings present in different guts ranged from 347 to 700. This shows that these fishes are mainly insectivorous in habit.

In addition to this, nearly 50 per cent of large quantities of macro vegetation like Caesalpinea leaves, bamboo leaves, blades of grass and large jumblum nuts have been found in the gut. In one stomach, 452 jumblum nuts showing a volume of 50·4 cc. were present along with the other macro vegetation, ants and beetles. This shows that this fish feeds on vegetation and fruits also.

(3) *Barbustor*—

| | |
|---|---|
| Size length | 33·7—43·5 cm. |
| Number of fishes | 6 |
| Length of guts | 156–86·5 cm. |
| Length of stomach | 28—46·5 cm. |
| Number of empty guts | 2 |
| Weight of gut contents | 4–5 gm. |
| Vol. of gut contents | 1–5·5 cc. |

*Gut analysis*—

Black ants, beetles, and insect appendages.

*Feeding habits.*—This seems to be definitely a purely insectivorus fish. It seems to feed on aquatic insects and black ants. The intestinal region is much narrower than in B. micropogon and showed only digested matter.

(4) *Callichrous pabda*—

| | |
|---|---|
| Size range | 8·1–8·9 cm. |
| Number of fishes | 3 |
| Length of guts | 10–11 cm. |
| Length of stomach | 1–1·5 cm. |
| Number of empty gut | 1 |

*Gut analysis*—

*Paramoecium* *Ulothrix*
*Rotifers* *Spirogyra*
*Rasbora*

*Feeding habits.*—The guts are longer than the length of the fish. The stomach is a short pear-shaped one with highly muscular walls which are produced into longitudinal folds. The oesophagus and intestines are very narrow. Of the three fish examined, the gut in one was empty. Of the other two, one showed ciliates, rotifers and green algae The other one showed a just-swallowed complete specimen of a 4 cm. long *Rasbora daniconius*. It was tightly packed in the one cm. long muscular stomach. *Callichrous pabda* is a carnivorous fish which can eat up a smaller fish nearly half its own length.

(5) *Discognathus lampta*—

| | |
|---|---|
| Number of fishes examined. | 5 |
| Size range | 11·1–14 cm. |
| Length of guts | 121—155 cm. |
| Stomach | Not differentiated. |
| Number of empty guts | 4 |

*Gut analysis*—

One beetle ; Hormidium ; Blue green algae.

*Feeding habits.*—Nothing could be definitely said about the feeding habits of *Discognathus lampta* till more specimens are examined. Out of the six guts examined four were empty. The only gut showed beetle and blue green algae. It is possible that this fish feeds on insects and plankton. The gut is uniformly slender, narrow and very compactly and spirally coiled. Stomach is not differentiated at all.

(6) *Saccobranchus fossilis*—

| | |
|---|---|
| Size range | 22—22·75 cm. |
| Number of fishes examined | 6 |
| Length of guts | 6—17cm. |
| Length of stomach | 1 cm. (average). |

*Stomach analysis*—

Chironomid worms ; *Cyclops.*
Insects heads 4—5 ; Protozoans (*Difflugia and Arcella*).
Insect parts ;
*Culex* larvae—2 ; Phytoplankton (*Closterium; Fragillaria and Phormidium*).
Insect larvae 8—10 ; Scales of fish 175
Shrimp 1–2 ; Fig seeds.
Rotifers Sand grains.
Gastropods (*Limnea* 50
*Planorbis* 2).

Daphnids ;

*Feeding habits.*—In the six guts examined, 90 per cent of their contents were insect parts, water insects, gastropods and scales and 10 per cent of sand grains. In one gut 50 *Limnea* and two Planktonic organisms were found. In another, shrimp, water insects, *Culex* larvae and other insect larvae were found. In another daphnids, *cyclops*, rotifers and phyto plankton, 175 scales of different sizes were found. This goes to confirm that in addition to being an insect and gastropod eater, this fish feeds on other smaller fishes. Being a bottom feeder this fish also perhaps feeds om scales of dead fish.

(7) *Ambassis ranga*—

| | |
|---|---|
| Number of fishes examined. | 3 |
| Size range | 6·5—8 cms. |
| Length of gut | 1·3—2·3 cm. |
| Length of stomach | 0·3—0·4 cm. |
| Weight of gut contents | Very negligible. |
| Number of empty guts | 2 |

*Gut analysis*—

*Camptocanthus* 2 ; copepods 3 ; *Diaphanosoma* 3 ; *Cypris* 2 ; Daphnids 2 ;

*Feeding habits.*—This is supposed to be a cyclopscidal fish. It seems to feed on zoo plankton mainly and copepods whenever available.

(8) *Barbus aurelius*—

| | |
|---|---|
| Number of fishes examined | 4 |
| Size range | 6·3—7·4 cm. |
| Number of empty guts | 2 |

*Gut analysis*—

*Euglena* ; copepod parts ; *Cypris* ; Daphnids ; Rotifers ; Insect appendages.

*Feeding habits.*—Of the two guts examined, one presented 50 per cent of *Euglena* and 50 per cent of other Zoo plankton. The other gut showed 75 per cent of zooplankton and 25 per cent *Euglena*. This is a plankton feeder.

(9) *Barbus melanampyx*—

| | |
|---|---|
| Number of fishes examined | 9 |
| Size range .. .. .. | 2·1–5·6 cm. |
| Number of empty guts .. | 5 |

*Gut analysis*—

Insect appendages ; insect heads ; beetles ; algal filaments.

*Feeding habits.*—Very little is so far known regarding the feeding habits of this fish. Of the four guts examined, all showed beetles and other insect appendages and parts. One of the guts showed a few parts of algal filaments. Two of the guts showed fine sand grains. This fish seems to feed on aquatic insects mostly.

(10) *Barilius bakeri*—

| | |
|---|---|
| Number of fishes examined. | 9 |
| Size range .. .. .. | 3·6 cm. |
| Length of guts .. .. | 4·5—8·5 cm. |
| Number of empty guts .. | 3 |

*Gut analysis*—

Rotifers ; gastropods ; insect parts ; shrimps ; algal filaments.

*Feeding habits.*—Of the five guts examined, all showed insect parts, and rotifers ; two showed gastropods and shrimps and one showed insect parts only and another showed algal filaments in addition to rotifers and insect parts. Evidently this is an insect feeder, feeding on insects and rotifers. Occasionally it may feed on algae also.

(11) *Botia historensis*—

| | |
|---|---|
| Number of fishes examined. | 6 |
| Size range .. .. .. | 3—6·1 cm. |
| Number of empty guts .. | 5 |
| Length of gut .. .. | 2·6 cm. |
| Length of stomach .. | ·5 cm. |

*Gut analysis*—

Insect parts ; insect appendages ; rotifers ; grubs of beetles.

*Feeding habits.*—This is a purely carnivorous fish. The only gut with food, was full of insect parts, beetle grubs and rotifers. This fish feeds on insect larvae and rotifers.

(12) *Etroplus maculatus*—

| | |
|---|---|
| Number of fishes examined. | 6 |
| Size range .. .. .. | 4·1—7·5 cm. |
| Length of guts .. .. | 3·1—11·2 cm. |
| Number of empty guts .. | 2 |

*Gut analysis*—

Insect parts, *Cyclops* ; Rotifers ; *Cypris*: Daphnids; *Ulothrix* ; *Spirogyra* ; *Navicula*; *Fragillaria* ;

*Feeding habits*—Of the four guts examined one showed insect parts only, three showed *Spirogyra Ulothrix* and other green algae. One showed *Cyclops*, rotifers, *Cypris*, *Diaphanosoma* and, etc., and two showed *Navicula* and *Fragillaria* in large numbers. Though this is supposed o be a cyclopeidal fish, it feeds on other zoo plankton and algae also.

(13) *Aplocheilus lineatus.*—Only two specimens were collected. They were 38 and 40 mm. long. Their guts were empty. Hence nothing could be observed regarding their food or feeding habits from this area.

(14) *Lepidocephalichthys thermalis*—

| | |
|---|---|
| Number of fish collected .. | 3 |
| Size range .. .. .. | 3·9—5·6 cm. |
| Length of guts .. .. | 1·3—2 cm. |
| Number of empty guts .. | 3 |

Nothing could be said about feeding habits as all the guts were empty.

(15) *Macropodus cupanus*—

| | |
|---|---|
| Number of fish examined. | 3 |

*Gut analysis*—

| | |
|---|---|
| Insect larvae ; | *Euglena.* |
| *Closterium* ; | *Fragillaria.* |
| *Spirogyra* ; | *Oscillatoria* |

*Feeding habits.*—All the three guts showed *Euglena*, green algae, diatoms and desmids. Two of the three guts showed insect larvae. This fish is supposed to be a good larvicidal fish. It can feed on algae and phytoplankton also.

(16) *Rasbora daniconius*—

| | |
|---|---|
| Number of fishes examined. | 3 |
| Size range .. .. .. | 7·2—7·7 cm. |
| Number of empty guts .. | 1 |

*Gut contents*—

Rotifers ; Nauplius larvae ; Algae ; *Spirogyra* ; *Fragillaria.*

*Feeding habits.*—Even the two guts examined were not full. This fish apparently had fed on algae, rotifers and other phyto plankton. This is supposed to be an insectivorous fish in hill streams.

*Fish Parasites.*—Trematode and nematode parasites were collected from the intestine of *Barbus tor* and *B. micropogon*. A few nematodes were also collected from the body cavity of *B. melanampyx*. These are being studied and described separately.

*Conclusions.*—Sixteen species of fishes were collected from the Periyar Lake and were studied for their food and feeding habits.

# UTILITY OF CHELA CLUPEOIDES AS A CYCLOPSCIDAL FISH IN STEP-WELLS

BY

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Control of water-borne diseases utilising larvicidal and cyclopscidal fishes has been advocated by many. Simply because under controlled conditions, certain species are avaricious eaters of insect larvae, cyclops, daphnids, etc., it does not indicate the same preference in natural waters where the carriers of water-borne diseases live and multiply in relation to other environmental conditions. It is therefore important to assess precisely the role played by larvicidal fishes in controlling the carriers in natural conditions.

There is no doubt that the best method is the use of chemicals which destroy all the planktonic organisms. However, in districts like South Arcot, there are a number of deep step-wells which are the usual and popular sources of drinking water. Protection of these step-wells from human infection or constant chlorination is not always possible. In these circumstances it will be useful to have complete information on the utility of individual species as live controllers of *Cyclops*.

Since they could be effectively controlled and fished easily, two step-wells in Alampoondi village were selected for the experiment. One of the wells was used as control and the other was stocked with *Chela Clupeoides*. Before the commencement of the experiments both the wells were cholorinated heavily to kill all life, especially plankton.

On 31st March 1957, 250 *chela clupeoides* were released into one of the wells. The villagers were instructed not to introduce murrels or any other fishes into the wells and not to catch experimental fishes. Monthly visits were made and dips of plankton were taken each time in the morning hours of 8 a.m. The dip net employed was similar to the type used by the public Health Department. This net can hold nearly 1·6 litres of water per dip. In all months, except April nearly a dozen *chela* were caught from the well by using a cast net and an equivalent number of *Chela* was introduced into it tokeep the total population constant. The guts of the captured *Chela* were examined and the number of *cyclops* and other organisms present were counted.

The data in Statement I show the actual number of early or larval crustaceans, *cyclops* and other crustaceans present in monthly dips. Part of the data for the first fortnight, every month was taken from the dip collection made by Gingee Health Inspector. Average of I and II fortnight dips were calculated. As there is usually a great percentage of mortality from larval stage to adult cyclops. the larval stages have been included under larval crustaceans and other crustaceans *Diaptomus* is indicated within brackets.

In the experimental well there is a definite reduction of *cyclops* and other crustaceans since May. In the control step well, density of cyclops is maximum in June and of daphnids in May and June. Again in November, *Cyclops* density is rather high, while control water shows only 85 (3) cyclops and 37 daphnids. When they occur in hundreds in control water only 55 *cyclops* occur in experimental water and in September, December and February, the experimental water shows less than 10 *cyclops*, being even as low as six in September, Hence, there is a definite reduction of *cyclops* in experimental waters. But *Chela* feeds also on daphnids in large numbers, if available.

From Statement II, the following points are evident. Even under normal conditions *cyclops* density is low in December and January while it is high in May and June, the maximum being in June. The low density of *cyclops* is perhaps due to loss of water which is baled out for irrigation and due to the excess of water during monsoon.

A total of 110 *Chela* have been collected with cast nets during the period of twelve months and examined. Fifty seven of the fishes showed adult *cyclops* at the rate ranging from 6 to 260 per gut. Ten guts showed appendages of *cyclops* up to 1,750 per gut. Thirteen of the guts were empty. The other 28 guts showed insets appendages and mosquito pupae up to 10 per gut. Besides, *Spirogyra* filaments, *cypris* shells and daphnids, were noted in very small numbers. The guts of *Chela* which contained *cyclops* also showed daphnids to a maximum of 7,330 in a gut. Twenty-five *Chela* showed daphnids, ranging from 120 to 7,330 per gut in addition to *cyclops* larvae, *cypris*, etc. On the whole only 23 per cent of *Chela* examined showed daphnids in large numbers.

*Conclusion*—

(1) *Chela* definitely checks *cyclops* population in large step-wells and hence prevents *Dracunculus* infection to some extent.

(2) *Chela* also feeds on daphnids, other insects and organisms. But 71 per cent of them feed on *cyclops* predominately.

(3) As mosquito larvae and pupae were found in the guts of *chela*, it can be used for anti-malaria stocking purposes also.

(4) Chlorination cannot be compared with *Chela* introduction in any water-piece as it is very costly and involves more labour and recurring expenditure. In spite of the cost and labour, 10 days after chlorination, plankton can be found in profusion. Hence, chlorination is effective only temporarily.

(5) *Chela clupeoides* though not 100 per cent effective in controlling *cyclops*, can certainly be preferred to chlorination in view of its low cost and easy availability. Chlorination however can be done a few times before May or June every year when there is maximum infection.

Introduction of *Chela* can be done with advantage nearly 7 days after a preliminary chlorination in any water-piece. This chlorination will get rid of *cyclops* as well as all other fish enemies like *snakes, frogs, etc.* Once 500–1,000 *Chela* are introduced in a water-piece there is no need for restocking. They will multiply in hundreds and feed on all the organisms including *cyclops* in the plankton. Thus, the infection could be most effectively checked in course of time. There will also be enough stock of *chela* for distribution to other infected waters.

I express my thanks to Dr. Ramakrishnan, of the Public Health department for having suggested suitable places in South Arcot District for starting the experimen. My thanks are also due to the Health Inspector, Guinea Worm Research, Gingee, for constant help during my monthly visits to Alampoondi village.

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(2) Strain R. E. (1942) Guinea-Worm infestation *Anticeptic, Madras*, 39, 29–30.

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STATEMENT I.—*Showing the number of organism per dip from Alampoondi wells from March* 1957 *to February* 1958.

| Period. | *Experimental well.* | | | *Control well.* | | |
|---|---|---|---|---|---|---|
| | *Larval Crustacean.* | *Cyclops.* | *Other Crustaceans (Daphnids).* | *Larval Crustaceans.* | *Cyclops.* | *Other Crustaceans, (Daphnids)* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| March 1957 .. .. .. .. .. .. | 170 | 88 | 99 | Nil. | Nil. | Nil. |
| April .. .. .. .. .. .. .. | 5 | 16 | Nil. | 23 | 37 | 15 |
| May .. .. .. .. .. .. .. | 73 | 159 | 24 | Nil. | 745 | 12,603 |
| June .. .. .. .. .. .. .. | 155 | 85+(3) | 37 | 327 | 1,528 | 11,142 |
| July .. .. .. .. .. .. .. | 67 | 31+(8) | 47 | 164 | 98 | 628 |
| August .. .. .. .. .. .. .. | 13 | 31+(12) | 12 | 51 | 18 | 1,537 |
| September .. .. .. .. .. .. | 9 | 6 | 7 | 20 | 23 | 52 |
| October .. .. .. .. .. .. .. | 8 | 8+(1) | 4 | 4 | 33 | 183 |
| November .. .. .. .. .. .. | 14 | 55 | 205 | 21 | 420 | 160 |
| December .. .. .. .. .. .. .. | 30 | 8 | 6 | 2 | 4 | 337 |
| January 1958 .. .. .. .. .. .. | 19 | 21 | 15 | 16 | 12 | 57 |
| February .. .. .. .. .. .. .. | 68 | 7 | 1 | 180 | 166 | 69 |

NOTES.—(1) Figures within brackets indicate Diaptomus which is not a host of Dracontiasis larvae.
(2) *Eucyclops leucarti,* which is intermediate host of the disease is the common cyclops recorded here.

STATEMENT II.—*Showing the data of cyclops density per dip in fish introduced and control wells, from April* 1956 *to March* 1957.

| *Month.* | *Well with chela.* | *Control well.* |
|---|---|---|
| (1) | (2) | (3) |
| April 1957 .. .. | 16 | 37 |
| May .. .. .. | 159 | 745 |
| June .. .. .. | 85 | 1,528 |
| July .. .. .. | 31+(8) | 98 |
| August .. .. .. | 31+(12) | 18 |
| September .. .. | 6 | 23 |
| October .. .. .. | (8+1) | 33 |
| November .. .. | 55 | 420 |
| December .. .. | 8 | 4 |
| January 1958 .. .. | 21 | 12 |
| February .. .. .. | 7 | 166 |
| March .. .. .. | .. | 2 |

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# A PRELIMINARY NOTE ON THE EXTERNAL GILL IN THE HATCHLINGS OF MYSTUS AOR (HAM) FROM THE 'SPAWNING PITS' IN BHAVANISAGAR RESERVOIR

BY

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Successful spawning of a fish is the vital factor that decides its ultimate fishery in any impounded multi-purpose reservoir. Investigations on the spawning grounds and their relative accessability by breeders are being carried on for each individual fishery at the Fresh Water Biological Station, Bhavanisagar. The two important fishes that have successfully established themselves and contribute nearly 25 per cent each of the experimental andings are *Puntius dubius* (Ham) and *Mystus aor*. A detailed paper on the Biology of *Puntius dubius* with reference to its growth and repopulation is under publication. The investigation on *Mystus aor* showed they become gravid by February and March and migrate from the reservoir towards the top waters for a very short distance. The narrow and yet not too deep lacustrine area with the gentle flow of the river clearly and perceptibly felt are the favourite spawning grounds. In these flats of depth varying from 1 metre to 3 metres the spawners select clay soil protected over a small rock, a dead stump of a tree, or even a twig safely inbedded in the soil and scoop pits varying from 8 c.m. to 15 c.m. deep and 38 c.m. to 56 c.m. in diameter, the size depending upon the size of the breeder. The intensity of the breeding can be visualised from the over 100 abandoned spawning pits counted in the exposed stretch due to water level going down within a distance of 150 metres on either side.

Between 28th March to 1st April 1962, the live 'spawning pits' were dived for and examined. The presence of the lethargic spawner, which happened to be the males in all the cases, was a sure indication of the availability of spawn. The contents of the pit were scooped out by hand. Stages from 8 m.m. to 3·5 c.m. were collected. The stages are being sketched and studied in detail. The water over the pit was turbid and laden with fine silt. It is likely the parent was over the pit and constantly aerating them. The mouth had opened out in hatchlings of 9.m.m. and above. In earlier hatchlings (8·3 to 8·5 m.m.) there was in addition, a cluster of four-lobed external gills projecting out from the posterior-most gill arch on each side. Under the microscope, the circulation of the colourless blood in these external gills was seen. This is a very interesting observation of adaptation in a species of a growing hatchling, in an ecological medium of low oxygen and a fair amount of laden silt. The development of external gills in fish Embryos have been recorded in all elasmobranchs, dipnoans, *Polypterus* and *Amia* (Fry 1957).

*Reference.*—Fry F. E. Aquatic respiration in fish—Physiology of Fishes—Acad Press, 1957.

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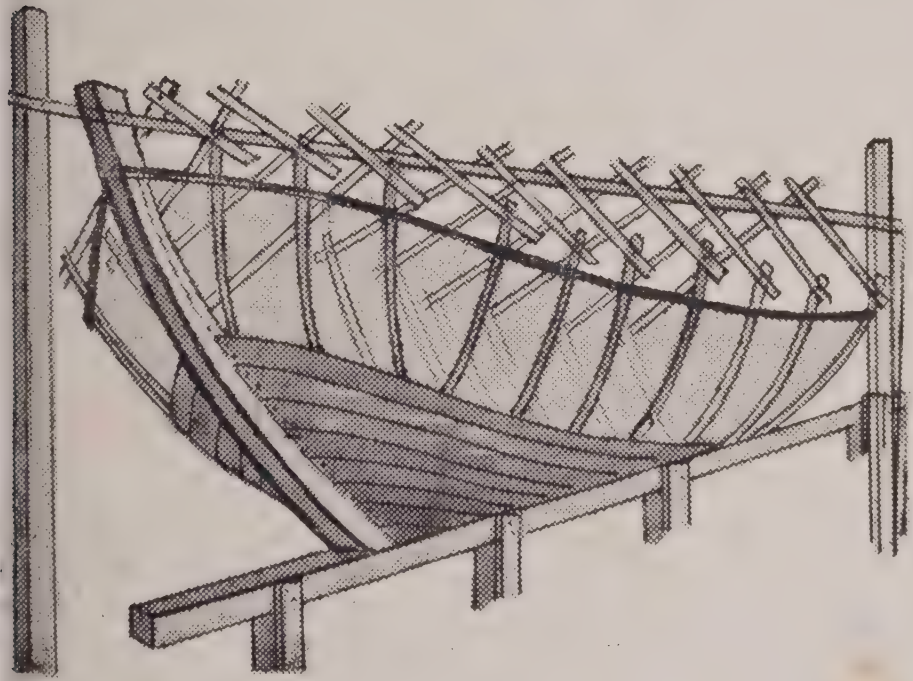

GOVT. FISHERIES BOAT BUILDING YARD, MARINA, MADRAS-5.

BUILDERS OF 30 FT. PABLO TYPE OF BOATS WITH 30 H.P. ENGINES FOR FISHERMEN FOR DEVELOPMENT OF MECHANISED FISHING.

# SEX DIMORPHISM IN BARBUS CURMUCA (HAMILTON)

BY

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Chetput, Madras.

*Barbus Curmuca* is one of the common carps occurring in the Periyar lake. During a survey of the fish fauna of this lake, 182 specimens of this carp were collected and examined in detail for the sex differentiative characteristics about which a preliminary note has been given by Raj (1955).

The specimens ranged from 40 to 401 m.m. in size. There were 77 males and 105 females. Maximum size noted was 410 m.m. in the case of male and 326 m.m. in female. The general colour pattern could be distinguished in three size-groups as shown below.—

| *Part of body.* | 40–100 *mm. size specimens.* | 101–200 *mm. size specimens.* | 210 *mm. and above sizes specimens.* |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 1. Body .. .. | Golden-yellow with silvery Ventral surface. | Light grey .. | Upper half light grey, Lower half light with silvery tinged scales. |
| 2. Paired fins .. | Grey with orange-in-between. | Grey with orange tinge. | Dark grey with white fringes. |
| 3. Anal fin .. | Nearly same length in both sexes. | Nearly same length in both sexes. | Longer in females. |
| 4. Caudal fin .. | Grey with golden tinge and orange blotch. | No orange blotch. | No orange blotch. |
| 5. Eyes .. .. | Red rim present. | Red rim present. | Red rim present. |

The pearl organs (horny tubercles) are the conspicuous sex characters of the males. These organs first appear as 1—3 tiny specks when the fish is about 130 m.m. in length, and thereafter form four to five prominent horizontally parallel rows from the snout to the eye. The number of pearl organs is about 16, 15, 20, 20 and 4 from the upper row downwards.

In the case of the larger females, no such characters are observed. The anal fin is distinctively longer than in male and even extends beyond the base of the caudal in some cases.

Sexual maturity as revealed by gonadial development is attained at 120-130 m.m. size in the male and 130–140 m.m. size in the female, the left ovary attaining an average of 64 m.m. in length and containing about 1,940 ova whereas the right ovary averages 70 m.m. in length containing 1,405 ova. The ripe ovarian egg is 1·4 to 1·8 m.m. in diameter. The ovary weighs 9 gms. in weight and 12 c.c. in volume on the average.

I am thankful to Sri P. I. Chacko, Assistant Director of Fisheries (I.M.B.) for affording facilities for conducting the study.

### *Reference.*

Raj, B. S., 1955.—Sexual Dimorphism in the Carp *Barbus* (*Puntius*) *curmuca* (*Hamilton*) *Rec. Indian Mus.*, 53, 377–378.

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# AN INSTANCE OF GONADIAL ABNORMALITY IN SARDINELLA SIRM

BY

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The ovary of *Sardinella Sirm* is asymmetrical, the right one being larger than the left. But in a specimen examined on 13th March 1961, the right ovary was absent totally without any trace and the left ovary occupied the entire abdominal cavity. This ovary measured 75 mm. in length and 4·5 gm. in weight and was in V stage of maturity containing transluscent eggs. The fish measured 185 mm. in length and 63 gm. in weight. This is the first instance of such gonadial abnormality in this species of Sardine.

# PRELIMINARY STUDIES ON THE USE OF INORGANIC FERTILISERS TO INCREASE FISH PRODUCTION

BY

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Bhavanisagar.

### Introduction.

The importance of fish as an indispensable item of nutrition for a country like India needs no emphasis.Though efforts have been made in recent years to increase fish production in this country, a great deal more of attention has to be directed to increase the productive potentialities of inland waters. There are two established methods by which fish-yield could be increased in the fresh water ponds—one by artificial feeding and the other through fertilisation. The former method has been known to be in vogue in China in the 4th and 5th century B.C. (Neess, 1949), but the application of chemical fertilisers to increase fish production has been developed only recently. The role of fertilisers has been the subject of study by several scientists and fishery workers for many years (Swingle and Smith, 1947) Neess 1949, Mortimer and Hickling 1954, Demoll 1925, and Holden 1959). Though a number of experiments on application of fertilisers have been carried out in temperate waters; such detailed studies have not been carried out under tropical conditions. Mortimer (1954) while reviewing the role of fertilisers in fish ponds had pointed out the complete absence of information on the effects of artificial enrichment in tropical ponds and the need for experimental work.

It has been confirmed by detailed experiments (Demoll, 1946, Schaeperclaus, 1958) that additions of fertilisers can, roughly double the productivity of European carp ponds. It can safely be anticipated that higher fish yield could be achieved by judicious addition of fertilisers in tropical fish ponds in view of the increased growth rate at higher temperature (Sklower, 1950). Hence, preliminary studies to assess the value of inorganic fertilisers in increasing fish production under tropical conditions were initiated at the Fresh Water Biological Station, Bhavanisagar.

### Experimental methods.

The experiments were conducted in cement tanks of size $6 \times 3 \times 1{\cdot}5$ metres. All the tanks were filled with the same type of soil up to 15 cm. depth, filled with water and then treated with fertilisers. The application of fertilisers to the cement tanks were made by broadcasting. Equal number of fingerlings were then introduced in all the tanks. At the end of the experiments the tanks were drained and the surviving fishes were weighed. Increase in production in kg/ha/year was calculated based on the total increase in weight in all the fishes.

### Results :—Series 1.

In the first series of experiments 4 tanks were taken up for study. *Tilapia mossambica* was the test fish used. All the tanks were uniformly stocked at the rate of 3,000 fingerlings/acre. On account of the importance of nitrogenous and phosphatic fertilisers, these two fertilisers in the form of ammonium-sulphate and super phosphate were chosen for the present experiments. Combination of ammonium-sulphate and superphosphate in the ratio 1:1 was also tried. One cistern was kept as control without the addition of any fertilisers. Fertilisers were applied to each tank once at the beginning of the experiment at 100 kg/ha and again after 30 days at 200 kg/ha. Total rate of fertilisers treated with was 300 kg/ha in each tank and the experiments were conducted for 3 months. The results are tabulated below :—

Table I.

*Experimental Series I.*

| *Treatment,* | *Survival,* | *Percentage increase in weight,* | *Production kg/ha/year.* |
|---|---|---|---|
| Control .. .. .. | 87 | 2,000 | 650 |
| Ammonium sulphate .. | 60 | 1,900 | 510 |
| Superphosphate .. .. | 73 | 6,200 | 1,735 |
| Ammonium sulphate + superphosphate. | 82 | 5,800 | 1,760 |

From the results tabulated, it is seen that the addition of superphosphate had significantly increased fish production. Combination of ammonium sulphate and superphosphate has increased the fish yield to 1,760 kg/ha as compared to 650 kg/ha in the control. Ammonium sulphate alone in fact had decreased the production and survival is also 60 per cent as against 87 per cent in the control tank. Moreover ammonim-sulphate itself had not in any way contributed to additional production when applied in combination with super-phosphate.

Regular plankton analysis was not carried out. But a dominant bloom of *Euglena* was observed in the tank treated with ammonium sulphate. It is apparent that there has been proportionate increase in the plankton bloom especially *Chlorophyceae* but there has not been any corresponding fish growth in the tank which could only mean that either the phytoplankton produced by application of ammonium sulphate was not consumed by the fish or that the ammonium sulphate added has a detrimental effect on the growth of fish. Depressing effect of ammonia on fish growth is well known (Kawamoto, 1961, Philips *et al* 1947).

**Results—Series II.**

In the second series of experiments in addition to ammonium sulphate and super-phosphate the effect of potash applied as muriate of potash (60 per cent $K_2O$) was also studied. In view of the encouraging results obtained with superphosphate, combination of superphosphate with ammonium sulphate and with potash were tried. The experiment was conducted over a period of 6 months, applying the fertilisers at 200 lb./ha. once in two months. Two species of fishes were introduced, *viz.*, *Tilapia mosambica* and *Labeo* species at the rate of 5,000 fingerlings/ha. Summary of results are presented in Table No. II.

TABLE II.

*Experimental Series II.*

| *Treatment.* | *Percentage of survival.* | *Percentage increase in weight.* | *Production kg/ha/year.* |
|---|---|---|---|
| Control .. .. .. | 20 | 266 | 38 |
| Ammonium sulphate .. | 20 | 473 | 95 |
| Superphosphate .. .. | 46 | 630 | 491 |
| Potash .. .. .. | 41 | 305 | 174 |
| Superphosphate + Ammonium sulphate. | 40 | 436 | 324 |
| Superphosphate + potash. | 50 | 671 | 532 |

Comparison of results clearly shows that superphosphate and potash together increased the fish production to 532 kg/ha against 38 kg/ha in the control tank. The survival too was maximum in the tank which was treated with superphosphate and potash. Next best yield was noted in tank treated with superphosphate alone, rather than in superphosphate and ammonium sulphate combination. This confirms the findings in the previous series. Phosphorus is the important single fertiliser as affirmed by many workers. The application of potash alone raised the fish production only to 175 kg/ha which is very much less than the effect of superphosphate when applied alone. It is shown from the above two series of experiments that the effect of ammonium sulphate in fish production is negligible. The results also show that potash is a superior fertilisers for application in combination with superphosphate.

Unfortunately the survival of *Labeo* species was too low for reasons not very clear. *Tilapia* bred profusely in all the cisterns and a large number of fry and fingerlings were collected. Breeding of *Tilapia* together with low survival of *Labeo* species might have been responsible for the low production in this set of experiments.

**Results—Series III.**

The effect of inorganic Nitrogen in the form of urea on fish growth was taken up for study in the third series. Besides superphosphate and potash, two different ratios were also tried to find out the optimum dosage. The application of fertilisers was altered to fortnightly treatment for three months to find out whether frequent application has any beneficial effect. The dosage applied was 50 kg/ha. Fishes introduced were *Catla catla*, *Labeo rohita* and *Cyprinus carpio* at the rate of 3,000 fingerlings/ha. The summary of results are presented below in Table No. III.

TABLE III.

*Experimental Series III.*

| *Treatment.* | *Survival percentage.* | *Percentage increase in weight.* | | *Production kg/ha/year.* |
|---|---|---|---|---|
| | | *Labeo rohita.* | *Cyprinus carpio.* | |
| Control .. .. | 63 | 168 | 74 | 112 |
| Superphosphate + potash (5 : 1). | 94 | 1,753 | 698 | 4,494 |
| Superphosphate + Potash (2 : 1). | 100 | 1,758 | 90 | 2,640 |
| Superphosphate + + Urea (4 : 1). | 69 | 1,873 | 74 | 1,932 |
| Urea + Potash (5 : 1). | Nil. | Nil. | Nil. | Nil. |

The table indicates that the best results were obtained with superphosphate and potash when applied in the proportion of 5 : 1, the production being 4,494 kg/ha almost twice that of the result obtained with the same combination when applied in the proportion of 2 : 1. The survival too has been very high with these two combinations. The effect of superphosphate and urea in the ration 4 : 1 gave fairly good results perhaps due to the effect of superphosphate only, the effect of urea being negligible as can be seen with the combination of urea and potash in the ratio 5 : 1. Initially dense growth of *Spirogyra* was noticed in the bottom for a month in the tank with urea and potash (5 : 1) but later *Chlorophyceae* blanketed this. There was zero survival of fishes in this tank. The excessive planktonic bloom might have caused the mortality of all the fishes by de-oxygenation or by release of ammonia. Manuring in this series has produced considerable increase in crop compared with the previous experiments. This can partly be attributed to the more frequent application of fertilisers and partly to the stocking of more compatible species.

**Changes in water conditions.**

The chemical changes following the application of fertilisers were also studied in the third series. Soil and water samples were collected before manuring, then six days after manuring and were analysed. Soils were analysed for their available nutrients (Spurway, 1946). Water samples were analysed by standard methods (APHA 1956). Changes in pH, dissolved oxygen, total dissolved solids and loss on ignition are represented in Fig. 5. Marked fluctuations were observed in dissolved Oxygen, pH and alkalinity in the fertilised tanks as compared with those of the control tank and this could be due to the increased biological activity of the fertilised tanks. (Hepher, 1958). Even though all water samples were collected between 8·0 and 9·0 a.m. to minimise the effect of photosynthesis, pH readings were above 9·0 and an appreciable amount of carbonate-alkalinity was present. Total dissolved solids which are known to be an indication of productivity of waters (Rawson, 1959) was found to be higher in all the treated tanks than in the control. Similarly loss on ignition (organic matter) was lower in the control tank. Ammonia was detected in the water only at certain times in tanks treated with Urea, while it was not detected in other tanks. Ammonia was lost from the water within six days. Ammonia content was not estimated. Determination of potassium was also not made. Phosphorous concentration of the waters of cement tanks found by analysis before and during fertilisation are given in Table IV.

TABLE IV.

*Phosphate content of waters of cement tanks in experimental series III (p.p.m.)*

| —— | *Prior to application.* (1) | *Date of application of manures:* 3rd *October* 1961. (2) | 19th *October* 1961. (3) | 3rd *November* 1961. (4) | 14th *November* 1961. (5) | 5th *December* 1961. (6) | 21st *December* 1961. (7) |
|---|---|---|---|---|---|---|---|
| Date of analysis .. .. | 2nd October 1961. | 29th October 1961. | 25th October 1961. | N.E. | 18th November 1961. | 11th December 1961. | 26th December 1961. |
| Control .. .. | Nil. | Nil. | Nil. | N.E. | Nil. | Nil. | Nil. |
| Superphosphate + Potash (5 : 1). | Nil. | 0·02 | 0·02 | N·E. | 0·08 | 0·02 | Tr. |
| Superphosphate + potash (2 : 1). | Nil. | Tr. | Tr. | N.E. | Nil. | Tr. | Nil. |
| Superphosphate + Urea (4 : 1). | Nil. | 0·06 | 0·02 | N.E. | 0·16 | Tr. | Tr. |
| Urea + Potash (5 :1 ). .. | Nil. | Nil. | Nil. | N.E. | Nil. | Nil. | Nil. |

Dissolved inorganic phosphate was not detected in any of the tanks before the commencement of the experiment. It was absent in the waters of the untreated tank throughout the period of the experiment. In tanks manured with superphosphate, phosphate was detected in the waters in quantities of 0·02 p.p.m. after the first two applications. Rigler (1957) has shown that of the total phosphorous added to the surface, 77 per cent was lost from the water to the plankton and 3 per cent to the mud. The disappearance of the phosphate from the water may be due to many factors such as uptake by plankton, mud, etc. After repeated applications phosphate was present only in traces which clearly shows that the increased plankton produced had taken up immediately almost all of the phosphate added. This is seen in all cases with superphosphate treatment. Zeller (1952) also made similar observations.

**Change in soil conditions.**

The data on the analysis of soils before and at the end of the experiment are given in table V.

TABLE V.

*Showing the concentration of soil nutrients with different fertilisers treatment.*

| *Treatment,* | *Control.* | *Super phosphate plus Potash* (5 : 1) | *Super phosphate plus Potash* (2 : 1), | *Super phosphate plus Urea,* (4 : 1) | *Urea plus Potash* (5 : 1) |
|---|---|---|---|---|---|
| Ammonia— | | | | | |
| (A) .. .. .. | 2 | 2 | 2 | 2 | 2 |
| (B) .. .. .. | 5 | 15 | 10 | 25 | 25 |
| Phosphate— | | | | | |
| (A) .. .. .. | Tr. | 0·5 | 0·25 | 0·25 | 0·25 |
| (B) .. .. .. | 0·25 | 0·75 | 0·75 | 0·75 | 0·75 |
| Calcium— | | | | | |
| (A) .. .. .. | 30 | 30 | 30 | 30 | 30 |
| (B) .. .. .. | 40 | 40 | 40 | 40 | 40 |
| Iron— | | | | | |
| (A) .. .. .. | Tr. | Tr. | Tr. | Tr. | Tr. |
| (B) .. .. .. | 2 | 2 | 2 | Tr. | 2 |
| pH— | | | | | |
| (A) .. .. .. | 7·8 | 7·3 | 7·3 | 7·3 | 7·5 |
| (B) .. .. .. | 6·5 | 6·5 | 6·5 | 6·5 | 6·5 |

NOTE.—A. Before application of fertilisers.
B. At the end of the experiment.

Though initially available ammonia was present in all the tanks in concentration of 2 p.p.m. after repeated application of fertilisers at the end of the experiment a difference was noted in the total content of ammonia in the different tanks. That treated with Urea had a higher ammonia content than other tanks. Occurrence of ammonia even in the unfertilised tanks indicated that Nitrogen was not the factor limiting algal growth (Zeller, 1952), Neess (1949) is of opinion that bacterial fixation can provide most if not all of the nitrogen required by a pond. Available phosphorus was present only in traces in the control tank while it was present at 0·025 p.p.m. in all the other tanks. This might have been due to the effect of previous manuring. At the end of the experiment slight increase in the available phosphorus content has been noted in all the tanks, the increase being greater in tanks getting superphosphate treatment. Soil pH decreased in all the tanks, while available Calcium and Iron content increased in all the tanks.

**Discussion.**

From the experiments it could be seen that artificial enrichment of a pond could bring about considerable increases in fish yield and that superphosphate is the efficient single fertiliser. The striking effect of phosphorus when applied as superphosphate on fish yield has been noted by many workers (Weimann 1939, Wunder 1949). It appears that phosphorus is the most important limiting factor controlling organic production in natural waters. Phosphate fertilisers are said to stimulate the activity of nitrogen-fixing bacteria and growth of plankton (Demoll 1925). Further, phosphate fertilisation seems to have a direct beneficial effect on fishes through a more efficient utilisation of dissolved calcium from water, which has been fertilised with phosphate (Phillips *et al* 1956).

Opinions differ regarding the beneficial effect of inorganic nitrogen fertilisers on fish growth since variable results are reported. However, the experiments conducted here confirm the viewth at inorganic nitrogen in the form of ammonium sulphate and urea does not have any favourable effect on the rate of fish production and they may even have harmful effects on fish (Walter and Nolte 1929). It has often been observed that nitrogenous fertilisers have stimulating effect on the growth of phyto-plankton (Swingle and Smith 1938) as noticed by the *Euglena* bloom.

From the results it can also be concluded that potassium alone is not a particularly effective fertiliser though Demoll (1925) obtained increased production by using potassium alone. When added in combination with phosphate, the yields are much better than when phosphate alone was applied. Holte (1932) also obtained similar differences in yield. Soils may respond better to potash where potassium deficiency existed.

## **Summary.**

From the three series of experiments conducted it is evident that the effect of phosphate on the growth of fish is very striking. Combination of superphosphate and potash in the ratio 5 : 1 appears to be by far the most suitable. The optimum dosage seems to be 50 kg/ha applied to fortnightly intervals Inorganic nitrogen in the form of ammonium sulphate and urea have adverse or negative effect on the fish growth. It should also be mentioned that the above experiments were carried out in cement tanks under controlled conditions and these obviously have certain limitations with regard to space, temperature seepage, etc. Similar studies have to be undertaken in natural ponds to confirm the above findings. However, the conclusions arrived at lead to highly optimistic assessment of the value of phosphatic fertilisers in fish ponds.

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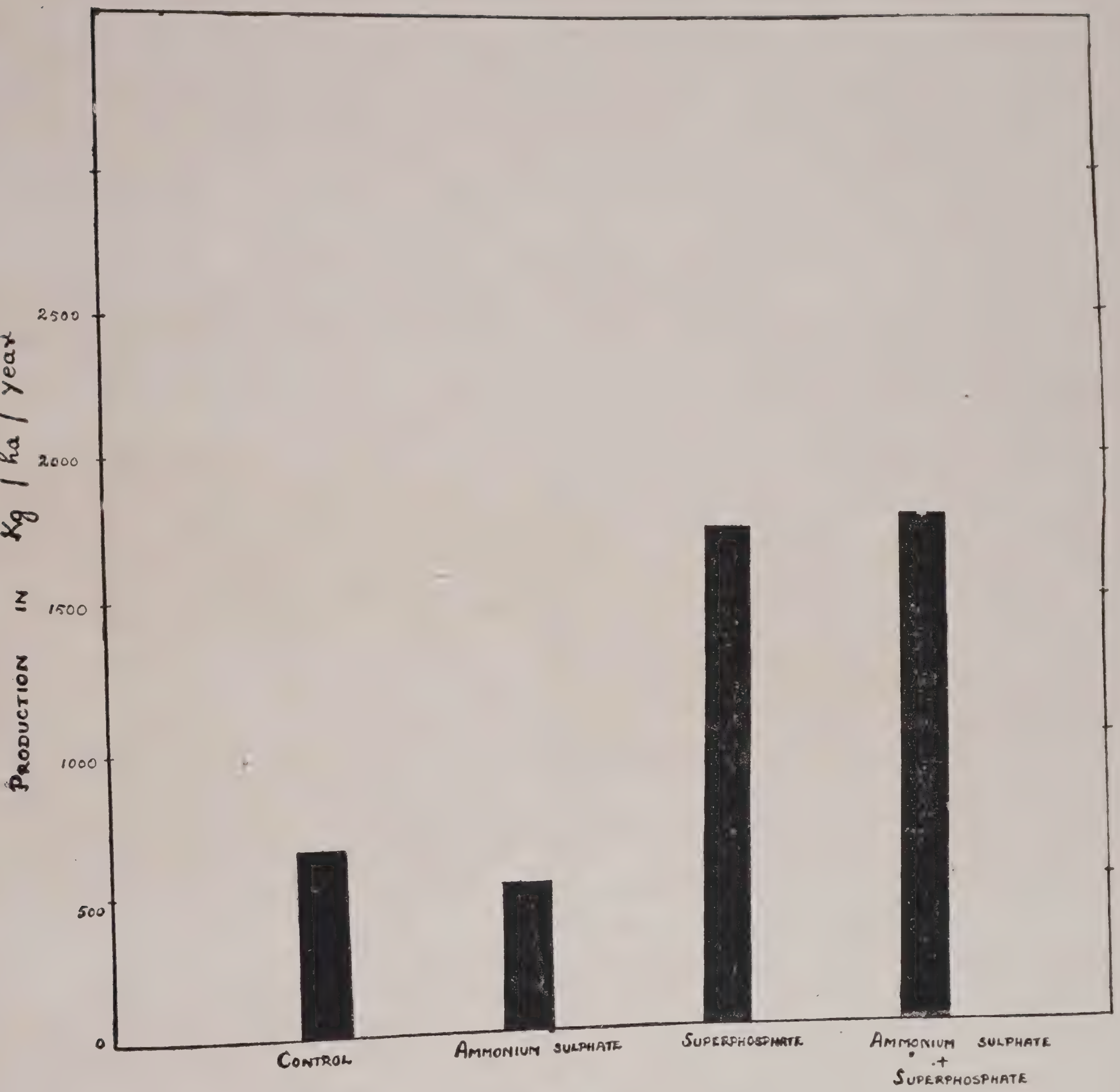

Fig. 1—Histograms showing the effect of fertilisers on fish production—Series I.

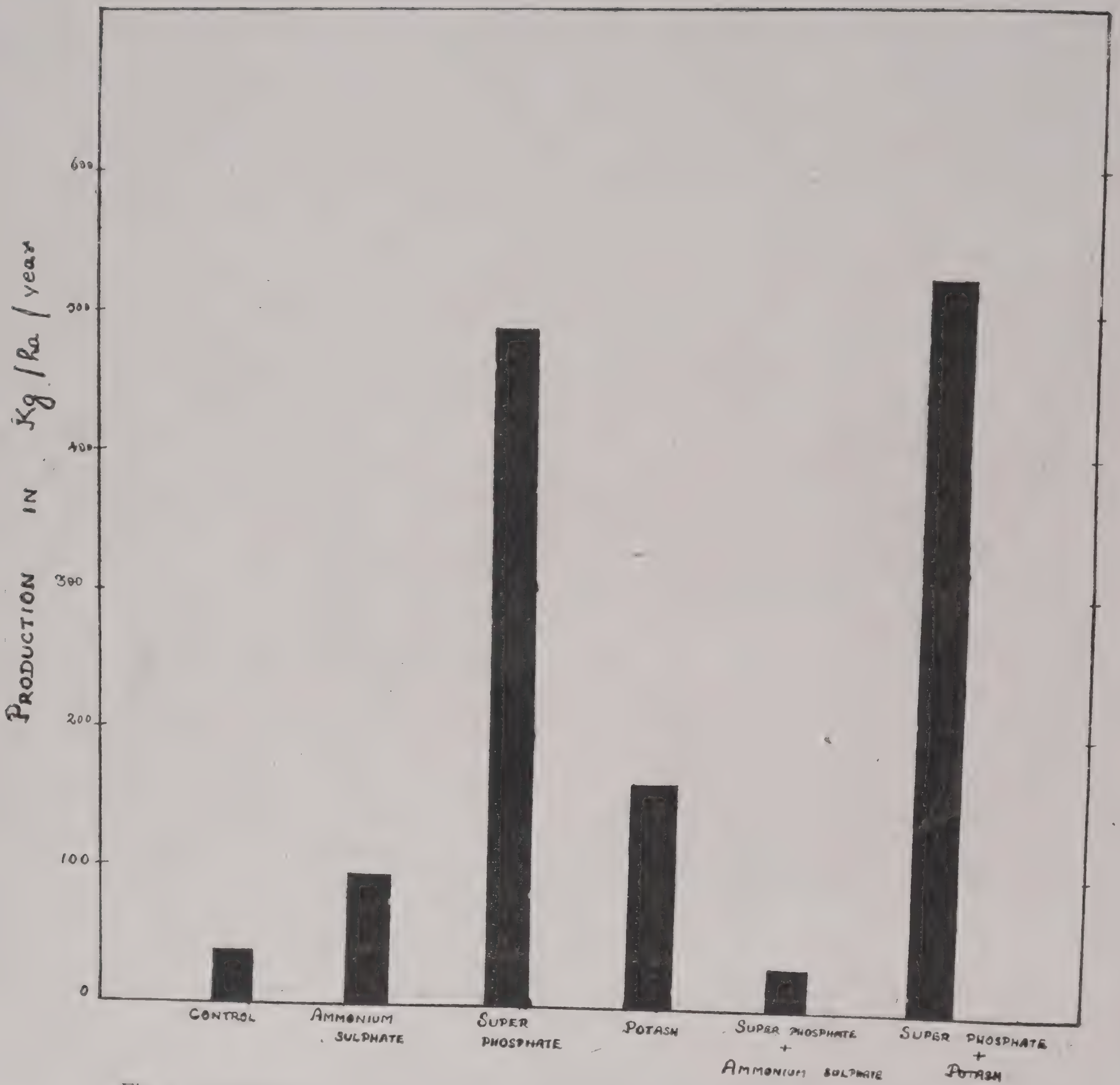

Fig. 2—Histograms showing the effect of fertilisers on fish production—Series II.

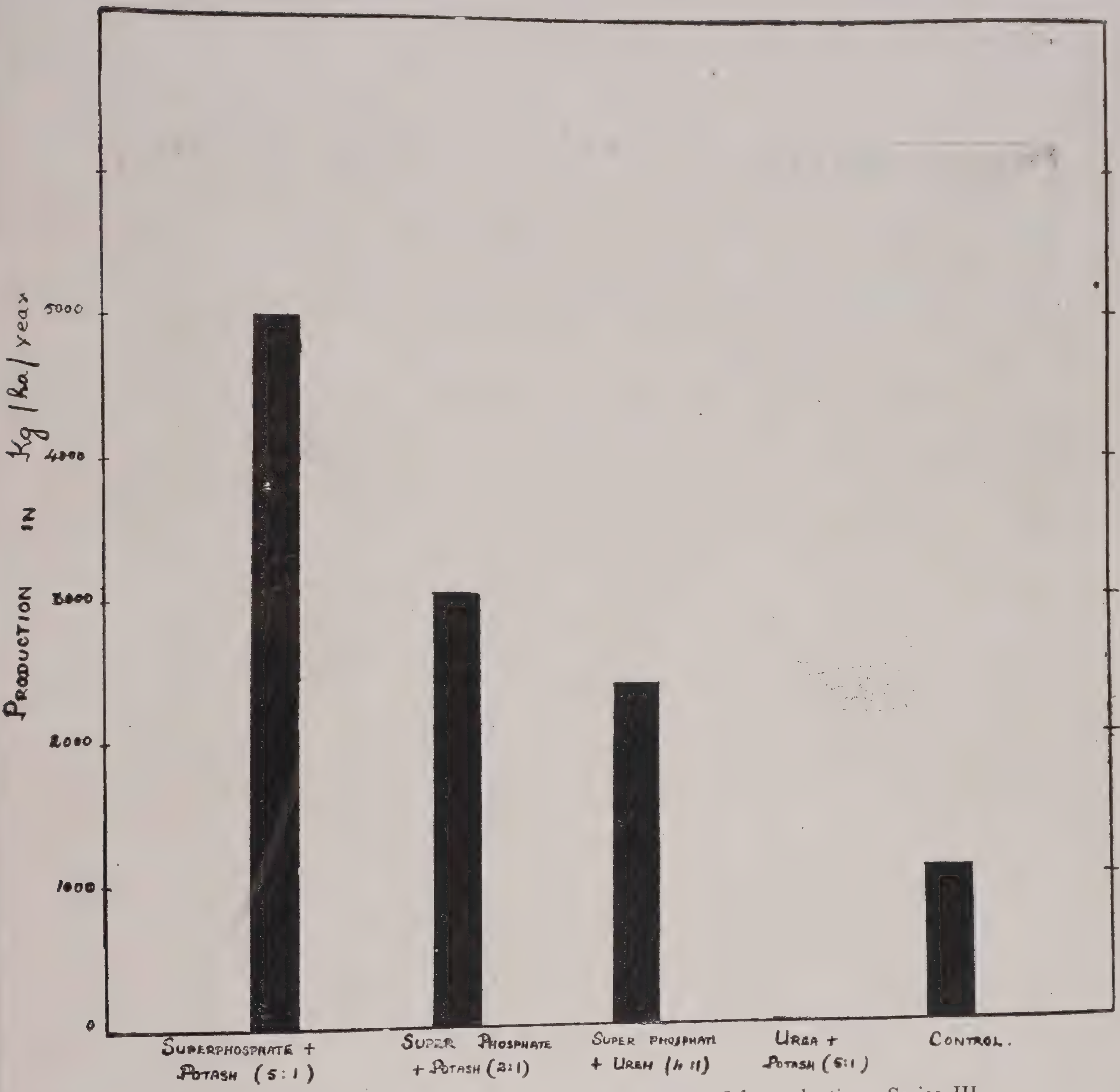

Fig. 3—Histograms showing the effect of fertilisers on fish production—Series III.

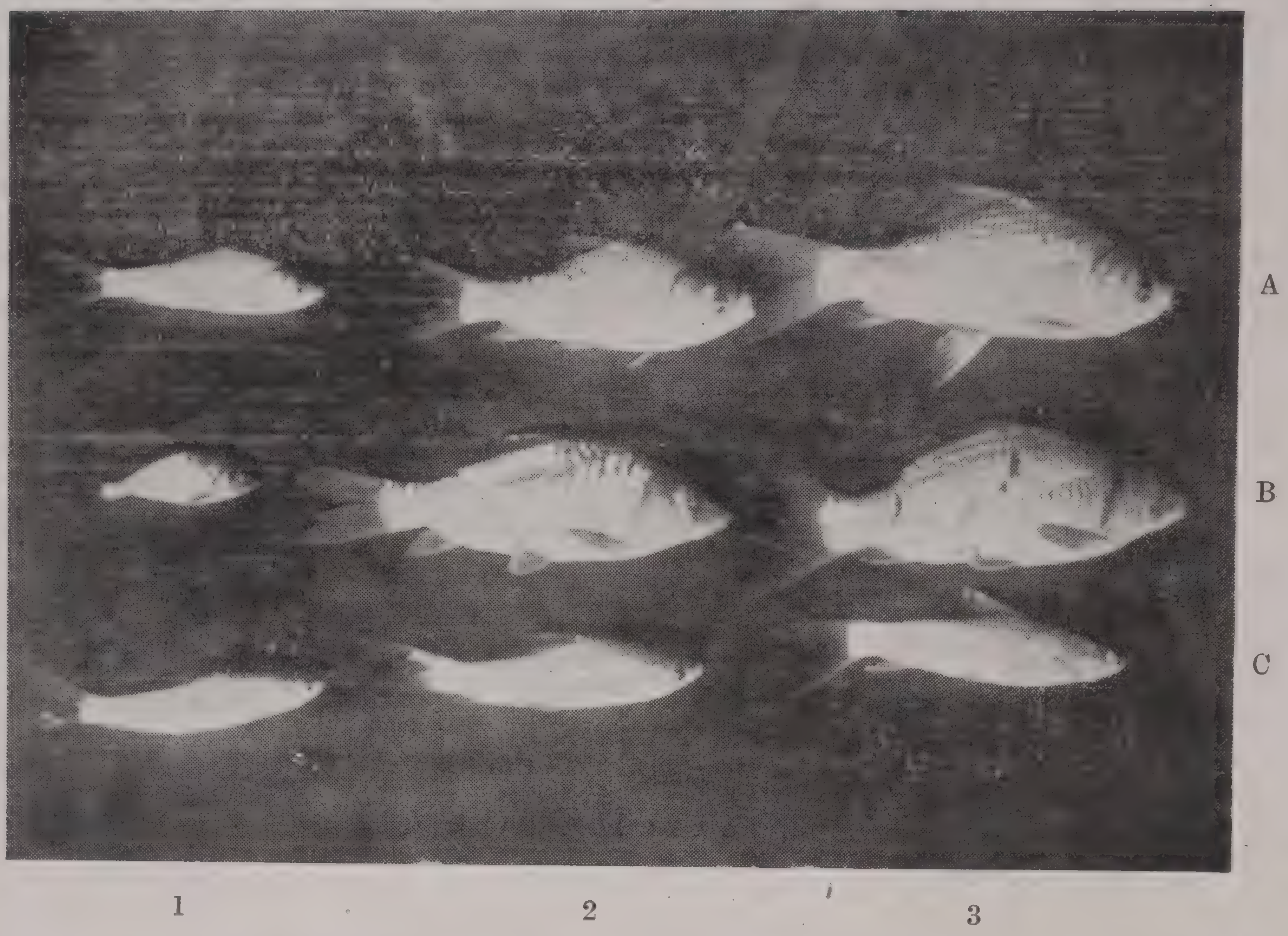

Fig. 4—Effect of Fertilisation on the growth of Fishes.

STOCKED : A—Catla Catla. B—Cyprinus Carpio. C—Labeo Rohita.

1. Average size in Control tank.
2. Average size in Tank treated with superphosphate and Potash 2 : 1.
3. Average size in Tank treated with superphosphate and Potash 5 : 1.

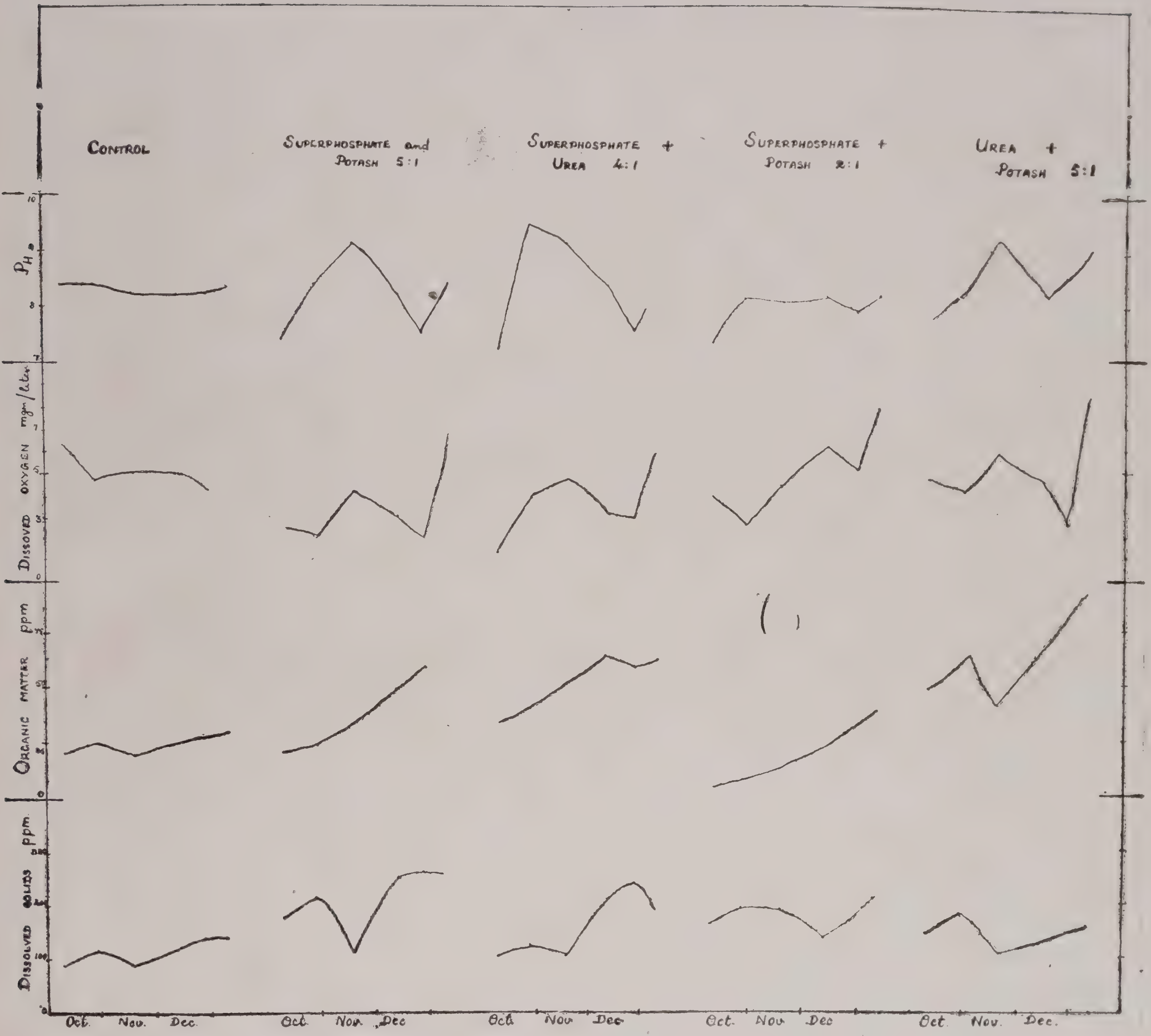

Fig. 5—Graphs showing the chemical changes in water during fertilisation.

# A SURVEY OF THE HYDROBIOLOGY AND FISHERIES OF THE COOUM RIVER

BY

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### 1. Description of the Cooum River.

The river Cooum starts from a surplus channel of a tank in the village Cooum situated in the Conjeevaram Taluk of Chingleput District. The river runs for about 40 miles before it enters the Madras City. Within the City limit itself it takes a meandering course for about seven miles and finally it joins the sea, a little to the south of Fort St. George. The total catchment area for the river is about 96 square miles.

Within the City limits there are ten bridges across this river which are as follows :—

1. Aminjikarai Bridge.
2. Nungambakkam Railway Bridge.
3. Munro's Bridge.
4. College Bridge.
5. Commander-in-Chief Bridge.
6. Harris Bridge.
7. St. Andrew's Bridge.
8. Law's Bridge.
9. Willingdon Bridge.
10. Napier Bridge.

After entering into the City and just before joining the sea, the river splits up into two branches which join again just before the Napier Bridge thus forming the Island Ground. The Buckingham canal joins the northern arm of the river and continues up to the southern arm of the river. This portion of the river is navigable. From the Southern arm the South Buckingham canal takes off.

The river Cooum is not a perennial one. It has flow only during North-East Monsoon from October to December. Water from about 7 square miles area of the City drains into the river. At the mouth of the river, i.e., the place where it joins the sea it is closed by a sand bar throughout the year except at times when there are heavy rains. The sand bar is due to deposition of sand at the mouth of the river by sea currents. Due to the tidal action of the sea the depth of water in the river varies greatly, especially at the portion of the river near the sea. Water level in the river falls when there is low tide and water level rises when there is a high tide. When the level of the water goes below plus 1·50 feet above mean sea level the shoals in the river covered with bottom deposits get exposed and cause obnoxious odours. In addition to this, the sullage from several un-sewered areas of the City finds an entry into this river by means of the Buckingham canal and causes nuisance. Another main reason for the unsatisfactory condition of the river is due to the water remaining stagnant for a major period of the year.

The river is practically dry at places above the railway bridge at Nungambakkam except for a few ditches having rain water collections. Storm water drains of the city have also been connected to the river at various points. This river is polluted in many respects and the major sources of pollutions are as follows :—

(1) A large number of slum areas are located on either side of the river margin at various places starting from Nungambakkam Railway Bridge up to Law's Bridge at mile No. 1. These slums contribute all types of pollution such as utensil washing, cloth washing and sullage water, etc.

(2) Drain bringing waters from cattle yards also joins the river near Munro's Bridge.

(3) The pits and ditches having rain water collections at places upstream of Nungambakkam Railway Bridge are polluted by washing of clothes by dhobies.

(4) People residing on the banks of the river dig pits on the river and store cow dung. People also defecate on the banks of the river in spite of public privies provided. Thus, human and animal wastes are washed into the river during rains.

(5) During heavy rains overflow of sewage (i.e., from Napier Park sewage pumping station) is also allowed to enter the river.

(6) Further, wastes from automobile workshops situated on the banks of river, garbage and rubbish from houses, shops and streets thrown on the banks of the river also contribute to the pollution of the river.

Owing to the heavy pollution of the river especially in upper reaches there is a small nuisance on most occasions owing to the prevalence of septic conditions. At certain reaches, i.e., portion between Munrow's Bridge and Willingdon Bridge, the dissolved oxygen content in water is as low as four parts per million parts and there is no fish life in that reach.

But the dissolved oxygen content in the water at portions close to Napier Bridge appears to be high which may mainly due to wind action and surface aeration.

The obnoxious odours appear to result when the level of the water in the river goes below plus 1·5 feet and it looks that smell nuisance can be minimised by maintaining a minimum water level of plus 1·5 in the river.

A sketch showing river Cooum and the bridges, etc., is appended.

## 2. Purpose and Method of Survey.

A regular monthly survey was conducted in 1958–59 in 4 sections of the river at Aminjikarai Bridge, Munro's Bridge, St. Andrew's Bridge and Napier Bridge, with a view to note the Physico-Chemical nature of the water, its plankton, fishery, number of fisherfolk, the craft and catch-effort, etc., and also to note if *Tilapia* would breed in the river. In 1961, another periodical survey of the same sections of the river was made along with stocking of *Tilapia* in the river. This report deals with both the surveys.

For nearly seven miles the river flows through the city and the estimation of population, of fish statistics, etc., are only confined to this region of the river.

## 3. Physico-Chemical Factors (Tables A1—A4).

The water colour, temperature, turbidity, depth and bottom for each section can be easily observed from the tabular statements. The last section will show in addition, the nature of the bar during the month. Usually the bar is open for two to three months during the year, i.e., from November-January but in 1961, due to heavy flooding in the river an artificial canal was cut by Public Works Department into the sea to prevent flood into the Madras City. Hence, the bar was open even after February.

*Section I—Aminjikarai Bridge.*—During January-May, September and November the water was clear, otherwise it was greenish or muddy. Temperature ranged from 26 to 32°C and turbidity from 44 to 56 c.m. Maximum depth was 9 ft. in November. Bottom was sandy at the banks and dark and clayey in the interior.

*Section II—Munro's Bridge.*—Water was clear from March to June and September, otherwise slightly muddy or slightly greenish. Temperature ranged from 26 to 33°C. Turbidity ranged from 38 to 44 c.m. Maximum depth was 7 ft. in November. Bottom was slushy and clayey.

*Section III—St. Andrew's Bridge.*—Water was never clear but was either blackish and muddy, reddish or dirty. Temperature ranged from 26 to 35°C. Turbidity ranged from 18·2 to 37·5 c.m. Maximum depth was 8 ft. in November. Bottom was of loose clay.

*Section IV—Napier Bridge.*—Water was clear from January to March, otherwise greenish, reddish, blackish or muddy. Temperature ranged from 26 to 36°C. Turbidity ranged from 34 to 45 c.m. Maximum depth was 10 ft. in November. Bottom of clean sand. Bar was open between November and January in 1957–59 and between November—February in 1961.

The water analysed in July 1961 and showed the following data :—

| *Section.* | *pH.* | *$O_2$ of cc/L.* | *$CO_2$ of P. small pm.* | *$CO_3$ of P. mall pm.* | *Bico$_3$ of P. small pm.* |
|---|---|---|---|---|---|
| I .. .. .. | 7·2 | 3·2 | 2·5 | 1·8 | 7·8 |
| II .. .. .. | 7·4 | 1·47 | 2·6 | 1·8 | 8·1 |
| III .. .. .. | 7·2 | 1·47 | 3·0 | 3·0 | 27·3 |
| IV .. .. .. | 7·6 | 3·29 | 2.2 | 2·4 | 26·5 |

## 4. Plankton (Tables B1—B5).

Plankton consisted of the following items of green algae blue-green algae, Diatoms, Desmids, Rotifers, Cyclops, Daphnids, Flagellates, young crustacean larvæ, insect larvæ, etc.—

| | |
|---|---|
| *Ankistrodesmus* | Green Algae. |
| *Pleurococcus* | |
| *Pediastrum* | |
| *Microspora* | |
| *Ophiocytium* | |
| *Tetraspora* | |
| *Spirogyra* | |
| *Ulothrix* | |
| *Dictyosphoerium* | |
| *Navicula* | Diatoms. |
| *Melosira* | |
| *Synedra* | |
| *Cyclotella* | |
| *Fragillaria* | |
| *Closterium* | Desmids. |
| *Gonatozygon* | |
| *Cosmarium* | |
| *Merotaenium* | |
| *Netrium* | |
| *Cyclops* | .. Copepods. |
| *Macrothrix* | Daphnids. |
| *Sida* | |
| *Daphnia* | |
| *Salpina* | Rotifers. |
| *Aneurea* | |
| *Floscularis* | |
| *Polyarthra* | |
| *Dinocharis* | |
| *Gastropus* | |
| *Suriella* | |
| *Euglena* | .. Flagellates. |
| *Volvox* | Colonial Flagellates. |
| *Pandorina* | |
| *Eudorina* | |
| *Carchesuim* | — Colonial Ciliate. |
| Nauplius larvae | |
| Insect larvae | |
| *Cypris* | |

Table B5 showing number of months of occurence of the organisms in the 4 sections.

| *Plankton organism.* | *I.* | *II.* | *III.* | *IV.* |
|---|---|---|---|---|
| Diatoms .. .. | 11 | 5 | 9 | 11 |
| Rotifers .. .. | 8 | 4 | 3 | 3 |
| Green algae .. .. | 6 | 10 | 4 | 5 |
| Blue Green algae .. | 5 | 4 | 8 | 6 |
| Desmids .. .. | 4 | 6 | 8 | 9 |
| Daphnids .. .. | 2 | 1 | 2 | 1 |
| Flagellates .. .. | 2 | Nil. | 2 | 1 |
| Nauplius .. .. | 2 | 4 | 1 | 1 |
| Cypris .. .. | 1 | Nil. | Nil. | Nil. |
| Copepods .. .. | Nil. | 4 | 3 | 2 |
| Colonial Ciliates — | Nil. | Nil. | 1 | Nil. |

The tabular statement B5 shows the periodicity of the occurrence of the different items of plankton in the different sections of the river. In general, the following factors are observed from the above table :—

(1) Diatoms are the predominant plankton of the river and occur in 11 months of the year in I to IV sections. On the whole, diatoms occur in all the sections of the river.

(2) Desmids are next abundant in II, III and IV sections of the river, while poor in the I section.

(3) Green algae occur in I and II sections more abundantly and are richest in section II.

(4) Blue-green occur in III and IV sections and is poorly represented in I and II sections.

(5) Daphnids, Flagellates, Nauplius, cypris, copepods, and colonial ciliates are comparatively rare in the river, because of unfavourable water conditions of the river throughout the City.

(6) Copepods were present only between August and November between II and IV sections and was most abundant in August and September.

(7) On the whole cyclops are scarce in the river.

## 5. Fish Fauna (Table C1—4).

The studies of fishery is based on only catches from trial nettings during the survey. The following fishes and macro crustaceans were found :—

1 *Ambassis nama*
2 *Amblypharyngodon mola*
3 *Anabas scandens*
4 *Barbus stigma*
5 *B. ticto*
6 *Chanos chanos*
7 *Chela argentea*
8 *Diagramma orientale*
9 *Discognathus lampta*
10 *Equula* sp.
11 *Etroplus Maculatus*
12 *Gambusia affinis*
13 *Labuca atpar*
14 *Lepidocephalicthys thermalis.*
15 *Lutjanus rivulatus*
16 *Macrones Vittatus*
17 *Mastacembelus armatus*
18 *Megalops cyprinoides*
19 *Metapenaeus monoceros*
20 *Mugil* sp.
21 *Nuria danrica*
22 *Ophiocephalus striatus*
23 *O. punctatus*
24 *Palaemon Lamarrei*
25 *Penaeus indicus*
26 *Rasbora daniconius*
27 *Sillago sihama*
28 *Therapon jarbua*
29 *Tilapia mossambica*
30 *Trichogaster fasciatus*

In addition to the fishes, prawns and lobsters mentioned above, crabs and molluscs, are found in the river. Pila and Limnea are the common gastropods present in the Cooum. The following points can be noted regarding the fishery :—

(1) *Penaeus indicus* and *B. Stigma* occur almost throughout the year in the I section of the river. *Glossogobius* and other Public Health fishes also occur in this section.

(2) *Metapenaeus monoceros* and *Palaemon Lamarrei* occur through out the year except July and August in II section of the river. *Barbus stigma* occurs 7 months in the year. *Chanos* was collected in March from this section

(3) *Prawns* occur 6 months during the year in the III section . *Megalops* occur in 4 months of the year. *Gambusia* has been netted only from this section of the river.

(4) *Barbus* sp. was almost absent in the IV section of the river and was netted only once in November.

(5) *Megalops* was common in the III section of the river.

(6) *Mugil* sp. (mullets) occur in III and IV sections of the river being most common in IV section between January and March.

(7) *Sillago sihama, Equula* sp. *Diagramma orientale* and *Therapon Jarbua* were collected from IV section when the bar was open and continued to occur even after the bar was closed, up to March or April.

(8) *Tilapia* has been netted only thrice during the survey from I, II and IV sections of the river.

(9) It is strange to note that while all other varieties of indigenous fishes (both fresh water and marine) crabs prawns and molluscs are thriving in the Cooum, only *Tilapia* has not established itself so far. Evidently, it is not the food conditions. Possibly other conditions are not suitabe for the thriving of Tilapia.

## 6. Gut analsis of Fishes—

(1) *Ambassis* : Blue-green algae ; Green algae Diatoms.

(2) *Ambly pharyngodon* : Green algae (*Ankistrodesmus Botryococcus* ; *Pleurococcus* ; *Diatoms*).

(3) *Anabas :* Insect appendages, Green algae ; Diatoms ; Fish eggs.

(4) *B. Stigma* : Rotifers ; Diatoms ; Desmids ; Volvox.

(5) *B. ticto* : Rotifers ; Diatoms ; Desmids ; Algae.

(6) *Chela* sp. : Rotifers (*Conochilus*, Rotifers) *Cyclops*, Copepods ; Diatoms ; Green algae (*Coelastrum* ; *Dictyosphaerium*).

(7) *Diagramma* sp. : Young crustaceans ; Rotifers ; *Macrothrix* ; *Nauplius, Daphnids, Cyclops* , Rotifers.

(8) *Discognathus* sp. ; Green algae ; *Nauplius* larvae.

(9) *Equula* sp : Desmids ; Diatoms ; Green algae.

(10) *Etroplus Maculatus* ; Copepods, Diatoms ; Green algae (*Spirogyra*) *Oedogonium.*

(11) *Gambusia affinis* ; Daphnids ; Cyclops ; Diatoms.

(12) *Glossogobius* : Green algae ; flagellates ; Diatoms.

(13) *Gobius* : Diatoms ; Desmids.

(14) *Lepidocephalicthys* sp. : Desmids ; Diatoms ; small scales.

(15) *Lutjanus* sp. : Nauplius ; copepods ; crustacean appendages ; Diatoms ; Algal filaments.

(16) *Macrones vittatus* : Cyclops ; Desmids ; Diatoms ; green algae ; crucigenia.

(17) *Mastacembelus* sp. : Diatoms ; Desmids ; Rotifers.

(18) *Megalops* : *Daphnia* ; *Crucigenia* ; *cyclops* ; *Diatoms.*

(19) *Mugil* sp. : Closterium Desmids ; *Synedra* ; *Navicula* ; *Suriella* ; *Pinnularia* ; *cymbella* ; Diatoms, Insect appendages ; *Polyarthra*; *Triarthra* ; *Notholca* ; Rotifers.

(20) *Nuria danrica* : *Botryococcus*, *Ankistrodesmus* *Pleurococcus* ; *Coelastrum*—Green algae.

(21) *Rasbora* sp : Crucigenia ; Green algæ ; Rotifers Nauplius larvae.

(22) *Therapon jarbua* : *Spirogyra* ; *Ulothrix*—Algae ; *Cymbella, Navicula*—Diatoms.

(23) *Tilapia mossambica* : Desmids ; Diatoms ; green algae ; *Crucigenia* ; Blue-green algae.

(24) *Trichogaster* sp. : *Cymbella* ; *Navicula*—Diatoms Green algae.

## 7. Statistics of Fish Landings (Tables D1—D4).

The fishery shown in these tables are those caught by the local fishermen of the particular section. The cost of fishes calculated for total value realised also varies from section to section according to the kind of fish, locality and prevailing market rate. This part of the report is compiled purely from statistics given by the local fishermen of the sections.

Number of fishermen were maximum in the III section (from Chintadripet down to the Gymkhana Club area) during the year. During November up to 50 fishermen were daily found fishing with Kacha Valai and rod and lines. As the bar was open, *Megalops* and Mullet fingerlings had come up into the river in thousands and this was the main attraction for the fishermen. Practically no fishing was done in this section in October. Next to St. Andrew's Bridge section, fishermen fished in large numbers in Munro's Bridge section. In Aminjikarai Bridge section and Napier Bridge section, the fishermen were fewer in number than those in the other 2 sections. During certain months of the the year, the Aminjikarai and Munro's bridge sections were dried up into little pools and narrow streams and there was usual flow only from the Connemara Bridge area.

*Craft and Tackle.*—All the fishermen in Aminjikarai bridge section used only cast nets. In Munro's bridge cast nets were the usual nets used with Kacha Valai in November and December. In St. Andrew's Bridge section Kacha valai was used mainly for fishing with rod and line in November and December. In the Napier Bridge section, January-May cast nets were used with rod and line in May. From June-September and December Kacha Valai was used.

*Fishery* (Table D1—D4).—Fishing was not done in III and IV sections in October. Inspite of this, section III has produced the maximum yield of 21,765 lb. and naturally more revenue to the fishermen of the area. I, II and IV sections have roughly produced an average of 15,000 lb. and an average revenue of Rs. 5,500—6,000.

## 8. Conclusions.

*Tilapia* thrives in most of the waters of the state and can stand high ranges of salinity in salt waters like the Kalimar lake in Manakudy. It has also established itself very well in the backwaters of Adyar river. Till 1958 *Tilapia* had not established itself in the Cooum river though the Inspector of Fisheries (Estuarine) had stocked the river with over 5,000 *Tilapia* seeds in 1958. About 39,400 *Tilapia* seeds ranging from 0·5 to 2·00 c.m. have been stocked in the different sections of the river and periodical trial nettings have been made by cast nets and Velon screen. The water temperature of Chetput fish farm and Cooum river is almost the same. *Tilapia* has not established itself satisfactorily in the Cooum and has been netted only thrice in 1961 from section I, II and IV.

The water analysis of Cooum showed a very low oxygen content, excess of $Co._2$, Carbonates and Bicarbonates in July 1961. The plankton, while rich in Diatoms and Desmids, is very poor in cyclops, and other phytoplankton. The oxygen requirement and feed of fishes vary from fish to fish and that is why perhaps when many other fresh water fishes, and salt water fish like *Megalops*, mullets, *Diagramma*, *Equulla* and *Therapon* thrive well with crabs, prawns, lobsters but Tilapia is unable to establish itself in this water. Small *Tilapia* seeds are perhaps unable to establish quickly. Nearly 5,000 *Tilapia* breeders of 15—20 cms. size have also been stocked in the river without any success. *Tilapia* recovered during my trial nettings were only 3—4 cms. in size and were evidently a few of the survived percentage that had existed in the river. It is however been reported that *Tilapia* was being marketed in some of the local markets. On enquiry these were reported to be caught from private tanks and Adyar river only.

*Tilapia* has not established itself successfully in Cooum. A thorough study of the Cooum water samples at different sections of the river compared with Chetput water is bound to show some factors which are causative in preventing the establishment of *Tilapia* in Cooum. Evidently the water conditions are not conducive to the growth of *Tilapia*. *Tilapia* if established will be a source of great revenue to the common fisher folk as even predators like *Notopterus* and Murrels cannot affect its population seriously, being a very prolific breeder.

The fishermen of the city who fish in Cooum thus have to depend for their income on the various indigenous fishes till such time as *Tilapia* is successfully established.

## Acknowledgment.

I am indebted to Sri P. I. Chacko , Assistant Director of Fisheries, for guidance during the survey and in the preparation of this report.

## TABLE A-1—A-4 PHYSICO CHEMICAL FEATURES.

### SECTION I (AMINJIKARAI BRIDGE).

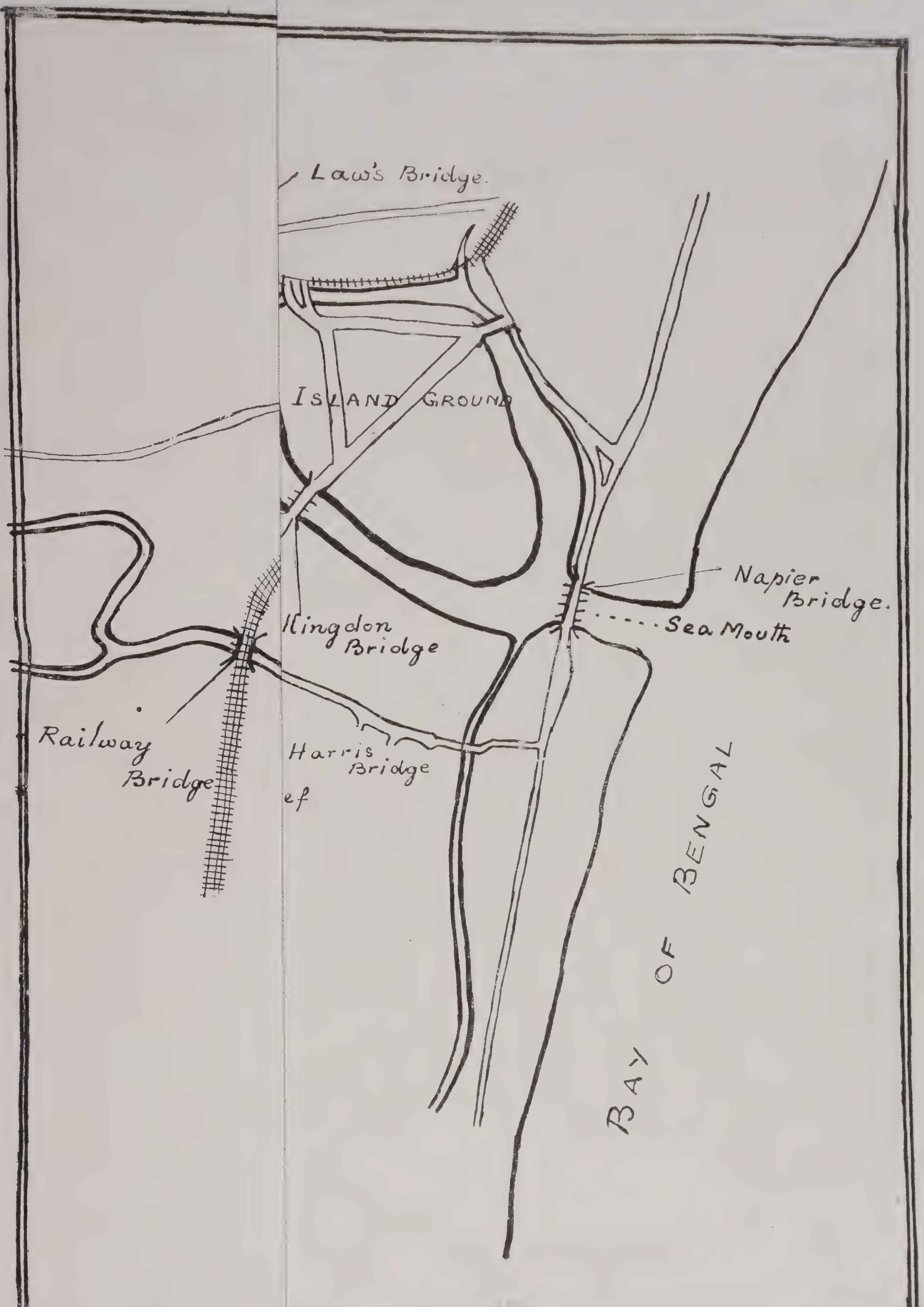
*Table—A I.*

| *Month.* (1) | *Colour of H2O.* (2) | *Temperature in °C.* (3) | *Turbidity in cm.* (4) | *Depth in ft.* (5) | *Bottom.* (6) | *Nature of bar.* (7) |
|---|---|---|---|---|---|---|
| January .. .. | Clear .. .. | 26 | 52 | 2–8 | Dark clayey and sandy at the bank. | .. |
| February .. .. | Do. .. .. | 27 | 50 | 2–8 | Do. | .. |
| March .. .. | Do. .. .. | 28 | 46 | 1–7 | Do. | .. |
| April .. .. | Do. .. .. | 30 | 44 | 1–7 | Do. | .. |
| May .. .. | Do. .. .. | 31 | 46 | 1–5 | Do. | .. |
| June .. .. | Greenish .. .. | 32 | 48 | 1–4 | Do. | .. |
| July .. .. | Do. .. .. | 29 | 50 | 1–3 | Do. | .. |
| August .. .. | Do. .. .. | 27 | 50 | 1–5 | Do. | .. |
| September .. | Clear .. .. | 29 | 26 | 1–6 | Do. | .. |
| October .. .. | Muddy .. .. | 26 | 52 | 1–7 | Do. | .. |
| November .. | Clear .. .. | 29 | 52·5 | 2–9 | Do. | .. |
| December .. .. | Green turbid .. | 26 | 52 | 2–9 | Do. | .. |

### SECTION II (MUNRO BRIDGE).

*Table—A II.*

| *Month.* (1) | *Colour of H2O.* (2) | *Temperature in °C.* (3) | *Turbidity in cm.* (4) | *Depth in ft.* (5) | **Bottom.** (6) | **Nature of bar.** (7) |
|---|---|---|---|---|---|---|
| January .. .. | Turbid .. .. | 29 | 42 | 1–5 | Slushy and clayey. | .. |
| February .. .. | Slightly muddy. | 28 | 42 | 1–5 | Do. | .. |
| March .. .. | Clear .. .. | 29 | 40 | 1–4 | Do. | .. |
| April .. .. | Do. .. .. | 31 | 38 | 1–3 | Do. | .. |
| May .. .. | Do. .. .. | 33 | 39 | 1–3 | Do. | .. |
| June .. .. | Do. .. .. | 33 | 39 | 1–3 | Do. | .. |
| July .. .. | Slightly blackish. | 30 | 42 | 1–4 | Do. | .. |
| August .. .. | Slightly greenish. | 30 | 40 | 1–4 | Do. | .. |
| September .. | Clear .. .. | 30 | 39 | 2–5 | Do. | .. |
| October .. .. | Muddy .. .. | 26 | 41 | 2–6 | Do. | .. |
| November .. | Do. .. .. | 31 | 43·5 | 2–7 | Do. | .. |
| December .. .. | Clear .. .. | 28 | 44 | 2–6 | Do. | .. |


Law's Bridge.
ISLAND GROUND
Napier Bridge.
Sea Mouth
Kingdon Bridge
Railway Bridge
Harris Bridge
ef
BAY OF BENGAL

## SECTION III. (ST. ANDREWS BRIDGE).

*Table—A III.*

| *Month.*<br>(1) | *Colour of $H_2O$.*<br>(2) | *Temperature in °C.*<br>(3) | *Turbidity in cm.*<br>(4) | *Depth in feet.*<br>(5) | *Bottom.*<br>(6) | *Nature of bar.*<br>(7) |
|---|---|---|---|---|---|---|
| January | Blackish | 26 | 36 | 1–7 | Very clayey loose clay, | .. |
| February | Blackish and muddy, | 28 | 30 | 1–6 | .. | .. |
| March | Green and muddy. | 31 | 20 | 1–6 | .. | .. |
| April | Blackish and muddy, | 35 | 20 | 1–5 | .. | .. |
| May | Greenish | 35 | 18 | 1–5 | .. | .. |
| June | Blackish | 34 | 20 | 1–4 | .. | .. |
| July | Reddish | 30 | 24 | 1–5 | .. | .. |
| August | Do. | 30 | 20 | 2–6 | .. | .. |
| September | Dirty | 30 | 18·2 | 2–7 | .. | .. |
| October | Muddy | 28 | 37·5 | 2–8 | .. | .. |
| November | Dirty | 31 | 36·5 | 2–8 | .. | .. |
| December | Blackish | 28 | 36·5 | 2–7 | .. | .. |

## SECTION VI (NAPIER BRIDGE).

*Table—A IV.*

| *Month.*<br>(1) | *Colour of $H_2O$.*<br>(2) | *Temperature in °C.*<br>(3) | *Turbidity in cm.*<br>(4) | *Depth in ft.*<br>(5) | *Bottom.*<br>(6) | *Nature of bar.*<br>(7) |
|---|---|---|---|---|---|---|
| January | Clear | 26 | 44 | 2–10 | Sandy of clean sand, | Open, |
| February | Do. | 30 | 42 | 2–9 | .. | Open artificially cut to prevent floods closed. |
| March | Do. | 29 | 40 | 1–7 | .. | Closed, |
| April | Blackish | 36 | 40 | 1–7 | .. | Do, |
| May | Greenish | 35 | 34 | 1–7 | .. | Do, |
| June | Reddish | 34 | 34 | 1–5 | .. | Do, |
| July | Blackish | 30 | 36 | 1–6 | .. | Do, |
| August | Reddish | 32 | 34 | 1–7 | .. | Do, |
| September | Greenish but clear, | 31 | 35·3 | 1–8 | .. | Closed 29–31, |
| October | Muddy | 29 | 37·5 | 2–9 | .. | Open, |
| November | Dirty | 30 | 45 | 2–10 | .. | Do , |
| December | Blackish | 28 | 45 | 2–10 | .. | Do, |

### TABLE B-I—B-IV

### SECTION I—(AMINJIKARAI

*Table*

| *Month.*<br>(1) | *Green algae.*<br>(2) | *Blue green algae.*<br>(3) | *Diatoms.*<br>(4) | *Desmids.*<br>(5) |
|---|---|---|---|---|
| January | .... | Coelosphoerium (∝) | Navicula (c)<br>Melosira (f) | .... |
| February | .... | .... | Synedra (c)<br>Cyclotella (f) | Closterium (c)<br>Gonotozygon (r)<br>Cosmarium (f) |
| March | .... | Coelosphoerium (∝) | Synedra (c) | .... |
| April | Ankistrodesmus<br>Pleurococcus, | .... | Navicula | Mesotaenium<br>Netrium |
| May | Do. | .... | Do. | Do, |
| June | .... | Coelosphoerium | Do.<br>Melosira | .... |
| July | .... | Coelosphoerium (c) | Melosira (c) | .... |
| August | Pediastrium (c) | .... | .. .. | .... |
| September | Do. | .... | .... | .... |
| October | Do. | Coelosphoerium (c) | Navicula (c)<br>Melosira (c) | Mesotaenium (c)<br>Netrium (c) |
| November | .... | .... | ...... | .... |
| December | .... | .... | Navicula (r)<br>Melosira (r) | .... |

### SECTION II

*Table*

| *Month.*<br>(1) | *Green algae.*<br>(2) | *Blue green algae.*<br>(3) | *Diatoms.*<br>(4) | *Desmids.*<br>(5) |
|---|---|---|---|---|
| January | Tetraspora (r),<br>Spirogyra (f), | Coelosphoerium (c), | .... | .... |
| February | Pleurococcus (f), | .... | Synedra (f).<br>Fragillaria (c) | .... |
| March | Spirogyra.<br>Tetraspara. | Coelosphoerium (c). | .... | .... |
| April | Ophiocytium,<br>Spirogyra,<br>Ankistrodesmus. | .... | Navicula, | Closterium. |
| May | Ankistrodesmus.<br>Pleurococcus,<br>Spirogyra,<br>Ophiocytium. | .... | Do. | Closterium.<br>Netrium. |
| June | Tetraspora (c)<br>Spirogyra (c) | Coelosphoerium (c), | .... | .... |
| July | Do. | Do. | .... | .... |
| August | Spirogyra (f).<br>Microspora (c).<br>Ulothrix, | .... | .... | Closterium (c).<br>Netrium (c), |
| September | Spirogyra (c).<br>Microspora (c)<br>Ulothrix (c) | .... | .... | Closterium (c).<br>Netrium (c) |
| October | .... | .... | Navicula (c). | Netrium (f)<br>Closterium (f)<br>Cosmarium (c) |
| November | .... | .... | .... | |
| December | Spirogyra (r).<br>Microspora (r).<br>Ulothrix (r). | .... | Navicula (c). | .... |

(∝) Indicates numerous.
(c) Indicates common.

(f) Indicafes few.
(r) Indicates rare.

—PLANKTON.
BRIDGE).
*B–I.*

| — | *Rotifers.* (6) | *Euglena.* (7) | *Daphnids.* (8) | *Nauplius.* (9) | |
|---|---|---|---|---|---|
| January .. .. .. | Salpina (f)<br>Rotifers (r) | .... | .... | | 3–5 |
| February .. .. .. | .... | .... | .... | Bar closed—Tilapia caught in trial netting, Megalops in 1 section. | 2–5 |
| March .. .. .. | Salpina (c)<br>Rotifers (r) | .... | .... | | 3–4 |
| April .. .. .. | .... | .... | .... | | 3–5 |
| May .. .. .. | .... | .... | .... | | 3–5 |
| June .. .. .. | Rotifers<br>Salpina | .... | .... | | 3–5 |
| July .. .. .. | Rotifers (c)<br>Salpina (c) | .... | .... | | 3–4 |
| August .. .. .. | Rotifers (c)<br>Salpina (c) | (f) | Macrothrix (∝)<br>Sida (∝)<br>Daphnia (∝) | C-Nauplius and other crustacean larvae. | 5–8 |
| September .. .. .. | Do. | (f) | Do. | C-Nauplius and other crustacean larvae (c). | 5–5 |
| October .. .. .. | .... | .... | .... | | 4–4 |
| November .. .. .. | Rotifers (f)<br>Salpina (f) | .... | .... | | 1–1 |
| Dcember .. .. .. | Rotifers (r)<br>Salpina (r) | .... | .... | Cypris (f) | 3–3 |
| | | | | | 38–54 |

(MUNRO BRIDGE).
*B-II.*

| — | *Rotifiers.* (6) | *Copepods.* (7) | *Daphmids.* (8) | *Crustacean larvae.* (9) |
|---|---|---|---|---|
| January .. .. .. | .... | .... | .... | .... |
| February .. .. .. | Anuraea (r)<br>Floscularia (f)<br>Polyarthra (f)<br>Dinocharis (r)<br>Gastropus (f) | .... | .... | Nauplius larva. |
| March .. .. .. | .... | .... | .... | .... |
| April .. .. .. | .... | .... | .... | .... |
| May .. .. .. | .... | Cyclops. | .... | .... |
| June .. .. .. | .... | .... | .... | .... |
| July .. .. .. | .... | .... | .... | .... |
| August .. .. .. | .... | Cyclops (c) | Macrothrix (f) | Nauplius larvae (c) |
| September .. .. .. | .... | Do. (c) | .... | Do. |
| October .. .. .. | Gastropus (c) | Do. (c) | .... | Do. |
| November .. .. .. | Do. (f) | .... | .... | Do. |
| December .. .. .. | Do. (∝) | .... | .... | .... |

(∝) Indicates numerous.
(c) Indicates common.
(f) Indicates few.
(r) Indicates rare.

SECTION III (ST.

*Table*

| *Month.*<br>(1) | *Green algae.*<br>(2) | *Blue green algae.*<br>(2) | *Diatoms.*<br>(4) | *Desmids.*<br>(5) |
|---|---|---|---|---|
| January | Ankistrodesmus (c)<br>Pleurococus (f). | Coelosphoerium | Navicula (f) | Cosmarium (f) |
| February | Ankistrodesmus (r)<br>Tetraspora (c) | Phormidium (c) | Navicula (f)<br>Synedra (c) | .... |
| March | Green algae (c) | Do. (∝) | Do. (f) | Do. (f) |
| April | .... | Do. (∝) | Do. (c) | Do. (c) |
| May | .... | Do. (∝) | Do. (f) | Do. (t) |
| June | .... | .... | Do. (f) | Do. (f) |
| July | Do. (f) | Do. (f) | Do. (c) | Do. (c) |
| August | .... | .... | .... | .... |
| September | .... | .... | .... | .... |
| October | .... | Do. (c) | Do. (c) | Do. (c) |
| November | .... | Oscillatoria (c)<br>Microcystis (c). | .... | Cosmarium (c)<br>Penium, (c)<br>Cyclotella, (c) |
| December | .... | .... | Do. (c) | .... |

SECTION IV

*Table*

| *Month.*<br>(1) | *Green algae.*<br>(2) | *Blue green algae.*<br>(3) | *Diatoms.*<br>(4) | *Desmids.*<br>(5) |
|---|---|---|---|---|
| January | .... | Phormidium.<br>Coelosphoerium.<br>Nostoc (f). | Navicula (c) | Netrium (r)<br>Penium. (r)<br>Cosmarium (f) |
| February | Ophiocytium (c)<br>Dictyosphoerium (f) | Spirulina (c).<br>Coelosphoerium (r). | .... | .... |
| March | .... | Do. (c) | Do. (f) | Do. (f) |
| April | Ankistrodesmus.<br>Dictyosphoerium.<br>Pleurococcus. | .... | Navicula. | Gonatozygon.<br>Netrium.<br>Mesotaenium. |
| May | .... | Do. (c) | Do. (c) | Do. (c) |
| June | .... | Do. (c) | Do. (f) | Do. (c) |
| July | Do. (c) | .... | Do. (c) | Do. (c) |
| August | Plankton richer in crustacean larvae than previous month. | | Do. (c) | Do. (c) |
| September | .... | .... | Do. (c) | Do. (c) |
| October | Do. (f) | .... | Do. (c) | Do. (c) |
| November | .... | Nostoc (c). | Do. (f) | .... |
| December | Do. (c) | .... | Do. (c) | .... |

Andrew's Bridge).

*B-III.*

| *Month.* | *Rotifers.* (6) | *Cyclops.* (7) | *Daphnids.* (8) | *Nauplius larvae Pandorina, lv ox.* (9) |
|---|---|---|---|---|
| January .. .. .. | .... | .... | .... | .... |
| February .. .. .. | Dinocharis (r)<br>Gastropus (f). | .... | .... | .... |
| March.. .. .. .. | .... | .... | .... | .... |
| April .. .. .. .. | .... | .... | .... | .... |
| May .. .. .. .. | .... | .... | .... | .... |
| June .. .. .. | .... | .... | .... | .... |
| July .. .. .. .. | .... | .... | .... | .... |
| August .. .. .. | .... | (∝) | (∝) | .... |
| September .. .. .. | .... | (∝) | (∝) | .... |
| October .. .. .. | Do. (c) | (c) | .... | Pandorina.<br>Volvox.<br>Colonial ciliates (∝)<br>Nauplius. |
| November .. .. .. | .... | .... | .... | Do. (f) |
| December .. .. | Do. (c) | .... | .... | Carchesium.<br>Colonial ciliates. |

(Napier Bridge).

*B-IV.*

| *Month.* | *Rotifers.* (6) | *Cyclops.* (7) | *Daphnids.* (8) | *Bar.* (9) |
|---|---|---|---|---|
| January .. .. .. | Dinocharis (f). | .... | .... | Partially open. |
| February .. .. .. | Frustulla (f).<br>Suriella(r)<br>Cyclotella (r). | .... | Macrothrix (f) | .... |
| March .. .. .. | Do. (c) | .... | .... | Plankton as dense as in February in the river. |
| April .. .. .. | .... | .... | .... | .... |
| May .. .. .. | .... | .... | .... | .... |
| June .. .. .. | .... | .... | .... | .... |
| July .. .. .. | .... | .... | .... | Plankton rich—bar closed. |
| August .. .. .. | .... | (∝) | .... | Bar closed First 11 section water was dirty and smelly. |
| September .. .. .. | .... | (c) | .... | .... |
| October .. .. .. | .... | .... | .... | Nauplius larvae (f) |
| November .. .. .. | .... | (f) | .... | .... |
| December .. .. .. | Do. (c) | .... | Flagellates. | .... |

**Tables C-1 to**

SECTION I—

*Table*

| *Month.*<br>(1) | *Murrel.*<br>(2) | *Cat-fish.*<br>(3) | *Prawns.*<br>(4) | *Glossogobius.*<br>(5) | *Tila pia.*<br>(6) |
|---|---|---|---|---|---|
| January | Murrel | Cat-fish | P. indicus | .... | .. |
| February | .... | .... | Do. | .... | .. |
| March | .... | .... | Do. | Glossogobius | .. |
| April | .... | .... | Prawns | .... | .. |
| May | O. punctatus | Cat-fish | Do. | Gobius .... | .. |
| June | Do. | .. | Do. | .... | .. |
| July | .... | Cat-fish | Do. | Gobius .... | Tilapia. |
| August | .... | .. | Do. | Mastcaembalus | .. |
| September | .... | .. | .. | Glossogobius | .. |
| October | No | Fish | was | netted | |
| November | O. punctatus | .. | Prawns | .... | .. |
| December | O. striatus | Cat-fish | .. | .... | .. |

SECTION II—

*Table*

| *Month.*<br>(1) | *Murrels.*<br>(2) | *Cat-fish.*<br>(3) | *Prawns.*<br>(4) | *Chanos.*<br>(5) | *Discognathus.*<br>(6) |
|---|---|---|---|---|---|
| January | O. striatus | .. | Metapenaeus monoceros. | .. | .. |
| February | .... | .... | Do. | .... | .... |
| March | .... | Mastacembalus and Cat-fishes. | Do. | Chanos | .... |
| April | .... | .... | Prawns | .... | .... |
| May | O. punctatus | .... | Do. | .... | .... |
| June | Do. | .... | Do. | .... | .... |
| July | .... | .... | .... | .... | .... |
| August | .... | .... | .... | .... | Discognathus. |
| September | .... | .... | Prawns | .... | .... |
| October | .... | .... | Do. | .... | .... |
| November | O. punctatus | .... | Do. | .... | .... |
| December | O. striatus | Cat-fish | Prawns, Palaemon Lamarrei and Metapenaeus monoceros occur in this section of the river. | .... | .... |

## C-4 Fishery.

(AMINIJIKARAI).

*C-I.*

| *Month.* | *Megalops.* (7) | *Mullets.* (8) | *B. stigma.* (9) | *E. maculatus.* (10) | *P.M. fishes.* (11) |
|---|---|---|---|---|---|
| January | .... | .... | .. | E. maculatus | .. |
| February | Megalops | .... | B. stigma | .... | .. |
| March | .... | Mullets | B. stigma and B. ticto. | E. maculatus | Chela, Nuria and Rasbora. |
| April | .... | .... | Barbus | Do. | .... |
| May | .... | .... | Do. | .... | .... |
| June | .... | .... | .. | .... | Chela and Labuca. |
| July | .... | .... | B. stigma | .... | Nuria. |
| August | .... | .... | Do. | .... | Rasbora and Amblypharyngodon. |
| September | .... | .... | Barbus and Rasbora. | .... | .... |
| October | .... | .... | .... | .... | .... |
| November | .... | .... | Barbus | ... | Chela. |
| December | .... | .... | Do. | .... | Lasbuca and Trichogaster. |

(CHETPUT BRIDGE).

*C-II.*

| *Month.* | *Glossogobius.* (7) | *Megalops.* (8) | *Mullets.* (9) | *B. stigma.* (10) | *E. maculatus.* (11) | *P.H. fishes.* (12) |
|---|---|---|---|---|---|---|
| January | Glossogobius | .... | .... | .... | .... | .... |
| February | .... | .... | .... | .... | .... | Labuca, Loaches Nuria. |
| March | Glossogobius | .... | Mullets | B. stigma | .... | Rasbora, Amblypharyngodon. Trichogaster. Chela, |
| April | Gobius | .... | .... | .. | .... | |
| May | .. | .... | .... | Barbus | .... | .... |
| June | Gobius | —.. | .... | Do. | .... | Chela. |
| July | .... | .... | .... | .... | E. maculatus. | Do. |
| August | .... | .... | .... | .... | .... | Nuria. |
| September | .... | .... | .... | Barbus | .... | .... |
| October | .... | .... | .... | Do. | .... | .... |
| November | .... | Megalops | .... | Do. | .... | .... |
| December | .... | Do. | .... | Do. | .... | ... |

SECTION III—

*Table*

| *Month.*<br>(1) | *Cat fish.*<br>(2) | *Prawns.*<br>(3) | *Diagramma.*<br>(4) | *Megalops.*<br>(5) | *Mullets.*<br>(6) |
|---|---|---|---|---|---|
| January .. .. | .... | P. monodon | Diagramma .. | .... | .... |
| February .. .. | .... | .... | .... | .... | .... |
| March .. .. | .... | P. monodon | Diagramma .. | .... | .... |
| April .. .. .. | .... | .... | .... | .... | .... |
| May .. .. .. | .... | .... | .... | .... | .... |
| June .. .. .. | .... | Prawns .. | .... | .... | .... |
| July .. .. .. | .... | .... | .... | Megalops | .... |
| August .. .. .. | .... | .... | .... | Do. | .... |
| September .. .. | .... | .... | .... | Do. | .... |
| October .. .. .. | .... | Prawns .. | .... | .. | .... |
| November .. .. | .... | Do. .. | .... | .. | Mullets (Fry). |
| December .. .. | Cat-fish.. | Prawns, Metapenaeus monoceros<br>P. monodon. | .... | Megalops | .... |

SECTION IV—

*Table*

| *Month.*<br>(1) | *Cat fish.*<br>(2) | *Prawns.*<br>(3) | *Sillago.*<br>(4) | *Glosso gobius.*<br>(5) | *Leiognathus.*<br>(6) |
|---|---|---|---|---|---|
| January .. .. | .... | .. | Sillago. | Glossogobius .. | L. sp. |
| February .. .. | .... | P. monodon | .... | .... | Neuyuveti. |
| March .. .. .. | .... | Prawns .. | .... | .... | .... |
| April | | | No fish collected during trial nettings. | | .... |
| May .. .. .. | .... | Prawns .. | .... | Gobius Ooden. | .... |
| June | | | Nil in trial nettings. | | |
| July | | | Do. | | |
| August | | | Do. | | |
| September | | | No fishes in trial nettings. | | |
| October | | | Do. | | |
| November .. .. | .... | Prawns.... | .... | .... | .... |
| December .. .. | Cat-fish .. | Prawns and<br>P. monodon. | Sillago .. | .... | .... |

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1. B. sp, is the only variety of P.H. fish collected from the section.

(Chintadripet Bridge).

*C-III.*

| *Month.* | *Eqlulna.*<br>(7) | *B. stigma.*<br>(8) | *E. maculatus.*<br>(9) | *P.H. Fishes.*<br>(10) |
|---|---|---|---|---|
| January | .... | .... | .... | .... |
| February | Equulla | .... | .... | .... |
| March | .... | .... | .... | Gambusia. |
| April | .... | .... | .... | .... |
| May | .... | .... | .... | Gambusia. |
| June | .... | .... | .... | Do. |
| July | .... | B. stigma | .... | .... |
| August | .... | .... | .... | Gambusia. |
| September | .... | .... | .... | .... |
| October | .... | B. stigma | .... | .... |
| November | .... | .... | .... | .... |
| December | .... | .... | .... | .... |

(Napier Bridge).

*C-IV.*

| *Month.* | *T. jarbua.*<br>(7) | *Lutjanus.*<br>(8) | *Mullets.*<br>(9) | *B. stigma.*<br>(10) |
|---|---|---|---|---|
| January | .... | Lutjanus sp. | .... | .... |
| February | .... | .... | Mullets | .... |
| March | Therapon jarbua | .... | Do. | .... |
| April | | No fish collected during trial nettings. | | |
| May | .... | .... | .... | .... |
| June | | Nil in trial nettings. | .... | .... |
| July | | Do. | .... | .... |
| August | | Do. | .... | .... |
| September | | Do. | .... | .... |
| October | | Do. | .... | .... |
| November | .... | .... | .... | Barbus sp. |
| December | .... | .... | .... | Barbus. |

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2. Gambusia are said to be collected.

## TABLES D1 to D4.

## Fishery, kind of craft and catch effort.

### SECTION I.

*Table D-1.*

| *Month.* | *Fishery.* | *Number of fishermen.* | *Kind of tackle.* | | | *Catch effort.* | *Total monthly landings.* | *Daily earning per fisherman.* | *Total value of fish exploited.* |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Cast net.* | *Rod and line.* | *Katcha Enthuvalai.* | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | | | | | | LB. | LB. | RS. nP. | RS. nP. |
| January | Murrels<br>Cat fish<br>Prawns<br>E. maculatus<br>Therapon | 5 | X | .. | .. | 6 | 930 | 2 00 | 310 00 |
| February | Prawns<br>Megalops<br>B. stigma | 5 | X | .. | .. | 6 | 930 | 2 00 | 350 00 |
| March | P. indicus<br>Mullets<br>B. ticto<br>Glossogobius<br>B. stigma<br>Chela<br>Nuria<br>Rasbora<br>O. punctatus, etc. | 6 | X | .. | .. | 6·10 | 1,860 | 3 00 | 558 00 |
| April | Barbus<br>Prawns<br>E. maculatus<br>O. punctatus<br>Gobies, etc. | 8 | X | X | .. | 4·8 | 1,680 | 3 00 | 620 00 |
| May | O. punctatus<br>Prawn<br>Gobies<br>Barbus | 13 | X | X | .. | 5·10 | 4,030 | 3 50 | 1,410 50 |
| June | Megalops<br>O. punctatus<br>Prawns, etc. | 7 | X | .. | .. | 5 | 1,050 | 1 00 | 315 00 |
| July | Cat fish<br>Prawns<br>Gobies<br>P. H. fishes | 5 | X | .. | .. | 3 | 465 | 1 00 | 155 00 |
| August | Prawns<br>Mastacembalus<br>B. stigma | 5 | X | .. | .. | 2 | 310 | 1 00 | 155 00 |
| September | Glossogobius<br>Misc. variety<br>Barbus<br>Rasbora, etc. | 5 | X | .. | .. | 2 | 300 | 1 00 | 150 00 |
| October | .... | No landings from this station. | | | | | | | |
| November | O. punctatus<br>Prawns<br>Chela<br>Barbus, etc. | 12 | .. | .. | .. | 6 | 2,160 | 2 00 | 720 00 |
| December | O. striatus<br>Cat fish | 10 | X | X | .. | 4 | 1,240 | 2 00 | 620 00 |
| | Total | 81 | | | | | 14,955 | | 5,363 00 |

X indicates kind of craft used in this section.

.. indicates Nil.

## SECTION II (CHETPET).

*Table D-II.*

| *Month.* | *Fishery.* | *Number of fishermen.* | *Kind of tackle* | | | *Catch effort.* | *Total monthly landings.* | *Daily earning per fisherman.* | *Total value of fish exploited.* |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Cast net.* | *Rod and line.* | *Katcha Enthuvalai.* | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | | | | | | LB. | LB. | RS. NP. | RS. NP. |
| January .. | O. striatus ..<br>Prawns ..<br>Lobsters ..<br>Glossogobius .. | 9 | X | .. | .. | 6 | 1,674 | 2 00 | 558 00 |
| February .. | Prawns ..<br>P.H. fishes .. | 9 | X | .. | .. | 6 | 1,512 | 2 00 | 630 00 |
| March .. | Mastacembelus ..<br>Cat fish ..<br>Prawns ..<br>Chanos ..<br>Mullets ..<br>P.H. fishes, etc. .. | 9 | X | .. | .. | 8 | 2,232 | 3 00 | 837 00 |
| April .. | Prawns ..<br>Gobius ..<br>Chela .. | 6 | X | .. | .. | 5 | 900 | 2 00 | 360 00 |
| May .. | O. punctatus ..<br>Prawns, etc. .. | 5 | X | .. | .. | 7 | 1,085 | 3 00 | 465 00 |
| June .. | O. punctatus ..<br>Prawns ..<br>Gobius ..<br>Chela ..<br>Barbus, etc. .. | 7 | X | .. | .. | 3 | 630 | 1 00 | 315 00 |
| July .. | Cat fish ..<br>P. H. fishes .. | 9 | X | .. | .. | 5 | 1,335 | 2 00 | 558 00 |
| August .. | Mullets ..<br>Prawns ..<br>Discognathus ..<br>P. H. fishes .. | 8 | X | .. | .. | 5 | 1,240 | 2 00 | 496 00 |
| September .. | Prawns ..<br>Megalops ..<br>Barbus, sp. .. | 5 | X | .. | .. | 4 | 500 | 2 00 | 300 00 |
| October .. | Prawns ..<br>Barbus ..<br>Gambusia .. | 5 | .. | .. | X | 2 | 310 | 0 75 | 116 25 |
| November .. | O. punctatus ..<br>Prawns ..<br>Megalops ..<br>Barbus .. | 12 | X | .. | X | 6 | 2,160 | 3 00 | 1,086 00 |
| December .. | O. straiatus ..<br>Prawns ..<br>Lobsters ..<br>Cat fish ..<br>Megalops .. | 11 | X | X | .. | 3 | 1,023 | 1 00 | 511 50 |
| | Total .. | 93 | | | | | 14,761 | | 6,226 75 |

**X** indicates kind of craft used in this section,
.. indicates Nil.

### SECTION III —(CHINTADRIPET),

*Table III,*

| *Month,* | *Fishery,* | *Number of fishermen,* | *Kind of tackle* | | | *Catch effort,* | *Total monthly landings,* | *Daily earning per fisherman,* | *Total value of fish exploited,* |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Cast net,* | *Rod and line,* | *Katcha Enthuvalai,* | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | | | | | | LB, | LB, | RS. nP, | RS. nP, |
| January .. | Prawns .. .. ..<br>Diagramma, sp, .. | 9 | .. | .. | X | 5 | 1,395 | 2 00 | 558 00 |
| February .. | Equulla .. .. ..<br>Other Misc, Varieties .. .. | 4 | .. | .. | X | 3 | 336 | 1 00 | 112 00 |
| March .. | Prawns .. .. ..<br>Diagramma .. ..<br>Megalops .. ..<br>Gambusia .. .. | 2 | .. | .. | X | 4 | 248 | 1 50 | 93 00 |
| April .. | Megalops .. ..<br>Gobius, etc. .. .. | 4 | .. | .. | X | 4 | 480 | 1 75 | 210 00 |
| May .. | Megalops .. ..<br>Gobius .. .. ..<br>Gambusia .. .. | 4 | .. | .. | X | 3 | 372 | 1 00 | 124 00 |
| June .. | Megalops .. ..<br>Gobius .. .. ..<br>Prawns .. .. .. | 2 | .. | .. | X | 3 | 180 | 1 50 | 90 00 |
| July .. | Megalops .. .. | 10 | .. | .. | X | 10 | 3,100 | 5 00 | 1,550 00 |
| August .. | Megalops .. ..<br>Mullets .. .. .. | 8 | .. | .. | X | 8 | 1,984 | 4 00 | 992 00 |
| September .. | Megalops .. .. | 9 | .. | .. | X | 5 | 1,395 | 2 50 | 675 00 |
| October .. | .... | | | | | Nil, | | | |
| November .. | Prawns .. .. ..<br>Mullets (fry) .. .. | 50 | .. | X | X | 8 | 12,000 | 2 00 | 3,000 00 |
| December .. | Cat fish .. ..<br>Prawns .. .. ..<br>Megalops .. .. | 3 | .. | X | X | 3 | 279 | 1 00 | 93 00 |
| | Total .. | 105 | | | | | 21,769 | | 7,297 00 |

X—Indicates kind of craft used in this section,
..—Indicates Nil,

## SECTION IV (IRON BRIDGE).

*Table IV-B.*

| *Month.* | *Fishery.* | *Number of fishermen.* | *Kind of tackle* | | | *Catch effort.* | *Total monthly landings.* | *Daily earning per fisherman.* | *Total value of fish exploited.* |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Cast net.* | *Rod and line.* | *Katcha Enthuvalai.* | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | | | | | | LB. | LB. | RS. NP. | RS. NP. |
| January .. | Mullets<br>Sillago<br>Glossogobius<br>Leiognathus<br>Lutjanus | 15 | X | .. | .. | 7 | 131 | 2 00 | 1,162 50 |
| February .. | Prawns<br>Mullets<br>Diagramma | 3 | X | .. | .. | 4 | 336 | 1 50 | 125 00 |
| March .. | Prawns<br>Mullets<br>Equulla<br>Gobies<br>Sillago | 15 | X | .. | .. | 10 | 4,650 | 3 00 | 1,743 75 |
| April .. | Prawns<br>Mullets<br>Equulla<br>Gobies<br>Sillago | 3 | X | .. | .. | 3 | 270 | 0 12 | 100 08 |
| May .. | Prawns<br>Gobies | 9 | X | X | .. | 5 | 1,395 | 2 00 | 588 00 |
| June .. | Mullets<br>Prawns | 10 | .. | .. | X | 3 | 900 | 1 00 | 300 00 |
| July .. | Megalops<br>Mullets | 9 | .. | .. | X | 5 | 1,395 | 2 50 | 697 50 |
| August .. | Megalops<br>Mullets | 8 | .. | .. | X | 6 | 1,488 | 3 00 | 744 00 |
| September .. | Megalops<br>Prawns | 4 | .. | .. | X | 5 | 600 | 2 50 | 300 00 |
| October .. | .... | | | | (No fisherman). | | | | |
| November .. | .... | | | | Do. | | | | |
| December .. | Cat fishes<br>Prawns | 4 | X | .. | X | 3 | 360 | 1 50 | 180 00 |
| | Total .. | | | | | | | | |

X—Indicates kind of craft used in this section.

..—Indicates Nil.

# A NOTE ON THE HYDROLOGY OF BHAVANISAGAR RESERVOIR FOR THE YEARS 1956-1961.

BY

SRI A. SREENIVASAN, HYDROLOGIST, BHAVANISAGAR.

Though excellent accounts of the Limnology of the American, European and African lakes are available, very little is known about the tropical impoundments and of the man-made lakes—Hutchinson's type 73. A summary of the Hydrological data obtained for the Bhavanisagar Reservoir, Madras State, is presented herein.

The Bhavanisagar reservoir has been formed by the construction of a dam below the confluence of the two rivers, Bhavani and Moyar both coming down the Nilgiri Hills. The area of the reservoir is 30·4 square miles, the volume of water impounded being 28,000 m.c.ft. The maximum depth is 100 ft. (33 m.). The data presented in Table I shows the annual variations in temperature, pH value and dissolved oxygen content of the surface and bottom waters of the reservoir proper and of the portions Bhavani and Moyar.

The annual variations in the temperature of water was very little especially in the reservoir but a large difference was noted (11·8°c) in Moyar in 1961. It was in 1961 that the lowest temperature was reached, *viz.*, 21·2°c in Moyar. An important feature continuously noted in the reservoir (which is not obvious from Table I) is the absence of a stable thermal stratification in fact there was none at all. Among other causes such as higher penetration of light, air temperature, etc., the absence of stratification may also be due to the fact that the hypolimnetic waters are discharged by the intakes that discharge water into the Canal and the river. The temperature curves for surface and bottom waters are very close to each other. The maximum surface temperature was reached in April–May following the air temperature to some extent, but the lowest temperature of surface water was not attained in December–January in parallel with air temperature, but in July–August following the floods in rivers (except in 1961). Since, the two rivers flow down from the hills with lower temperature, they influence the thermal structure of the reservoir much more than does the air temperature. The surface temperature of the waters was always less than the air temperature.

Except for one month, Phenotphthalein alkalinity was invariably absent in 1956 even in surface waters and free carbondioxide was present. A pH value above 8·2 was reached only once during the period when free carbondioxide was absent. A very high pH value of 9·1 was reached in 1957 in Bhavani concomitant with oxygen super saturation over 100 per cent for a brief period in December. By 1958 oxygen, supersaturation was noted for brief period in the surface waters, with a high pH value reaching 8·9. Alkalinity in the surface waters and even in bottom waters became more evident. Oxygen saturation progressively increased in 1959 and in 1960 it exceeded 200 per cent, in surface waters and even the bottom waters were supersaturated. However Hypolimnial oxygen deficit occurred in the Reservoir and Bhavani in March and May of 1960. The high oxygen super saturation was followed by the appearance of nitrate in the reservoir and Bhavani waters—for the first time in five years. A comparison of Dorairajah's data (1956) for the surface water of the reservoir in 1954, shows the progressive increase in pH, oxygen concentration and alkalinity since then. From the data furnished, it could be seen that the dissolved oxygen of surface waters was never a limiting factor for fish, since oxygen saturation was well above the limits prescribed.

The gradual warming up of the waters from 1956 to 1961 is evident from Table No. I.

Silicate content did not appear to be influenced by the floods and varied from 2·0 to 12·0 p.p.m. Inorganic phosphate has not so far been detected in these waters. Many authors have mentioned that the high phosphate content of coastal waters of the seas during floods was due to influx of river waters carrying large amounts of phosphates. However, even during floods, neither Bhavani nor Moyar carried any detectable amount of phosphate. A survey of the distributaries of the rivers Cauvery and Coleroon for one year (unpubl. results) also failed to indicate detectable quantities of phosphates at any time of the year. At least under our conditions, phosphates are not contributed by the rivers to inshore seas. This confirms the views of Rao and George. Nitrate estimation taken up since November 1961 indicated the presence of nitrate in the bottom water of the reservoir in December and also in surface water of river Bhavani. The electrical conductivity of the reservoir water was found to increase with depth confirming the observations of Edmondson (1953).

A study of the reservoir soil indicated a high ammonia between December and April. This is mostly due to decomposition of nitrogenous matter. Since nitrates were detected during December and May, the inference is that ammonia gets oxidized. The soil had a higher available phosphorus in July-August but this was never reflected in the water at any time.

Detailed account of this work will be published elsewhere

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TABLE I.

*Range of Certain Hydrological Factors in the Bhavanisagar Reservoir and the Rivers Bhavani and Moyar for the Year 1956–61.*

| *Year.* | | *Temperature °C.* | | | pH | | | *Dissolved oxygen mg./L.* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Bhavani,* | *Reservoir,* | *Moyar,* | *Bhavani,* | *Reservoir,* | *Moyar,* | *Bhavani,* | *Reservoir.* | *Moyar,* |
| 1956 .. | S | 23·7—30·8 | 23·8—29·3 | 24·8—30·2 | 7·1—8·4 | 7·1—8·7 | 7·2—8·5 | 2·0—8·0 | 3·0—7·9 | 2·5—8·2 |
| | B | 22·5—28·4 | 23·2—28·1 | 23·1—28·1 | 6·6—8·3 | 6·7—7·0 | 6·8—8·4 | 0·0—7·0 | 0·0—6·1 | 0·0—6·0 |
| 1957 .. | S | 26·3—29·6 | 27·2—29·4 | 25·6—29·8 | 7·3—9·1 | 7·6—8·9 | 0—8·9 | 2·3—8·5 | 4·5—6·8 | 4·4—7·6 |
| | B | 25·2—27·3 | 25·2—27·4 | 25·0—27·1 | 6·5—8·0 | 6·5—8·0 | 6·7—8·5 | 0·7—5·9 | 0·2—3·7 | 0·4—5·8 |
| 1958 .. | S | 26·5—30·7 | 26·8—30·8 | 26·4—30·3 | 7·5—8·9 | 7·4—8·9 | 7·4—8·8 | 4·9—8·4 | 5·0—9·1 | 4·3—8·4 |
| | B | 24·8—29·6 | 25·0—30·0 | 25·2—29·6 | 6·9—8·0 | 6·6—8·2 | 6·8—8·1 | 0·3—5·9 | 0·2—6·8 | 0·0—6·5 |
| 1959 .. | S | 28·0—30·0 | 27·8—30·2 | 27·8—30·2 | 8·0—8·8 | 8·2—8·7 | 7·2—8·7 | 5·0—15·1 | 2·7—12·9 | 5·5—12·9 |
| 1960 .. | S | 27·0—30·8 | 26·4—31·0 | 26·8—31·0 | 7·9—8·8 | 8·0—8·7 | 8·1—8·7 | 6·2—21·0 | 4·4—20·0 | 4·8—19·8 |
| | B | 24·4—29·4 | 24·0—29·4 | 24·0—29·2 | 6·8—7·6 | 6·7—7·6 | 6·7—8·5 | 0·0—14·0 | 0·0—12·0 | 0·1—10·2 |
| 1961 .. | S | 21·9—31·8 | 24·1—31·0 | 21·2—33·0 | 7·5—8·5 | 7·4—8·7 | 6·7—8·7 | 5·6—7·8 | 5·2—9·1 | 4·6—9·0 |
| | B | .. | 22·3—30·2 | .. | .. | 6·9—7·9 | .. | .. | 0·0—8·0 | .. |

S = Surface. B = Bottom.

# A NOTE ON THE USE OF AUREOMYCIN AS GROWTH PROMOTOR FOR FISH.

BY

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Artificial feeding of fish assumes importance in pond fish culture, as well as in hatcheries and nurseries. In trout hatcheries, artificial mixture of food is used to increase growth as well as "condition" of fish (1–3). However, these costly mixtures, though used in foreign countries, cannot be made use of in our country. Cheaper proteinaceous feeds such as oil seed cakes are available in plenty and it should be possible to make use of them. One of our problems in fish culture is lack of suitable nursery sites to rear fry into fingerlings, stage before stocking in cultivable waters. To this end any growth promoting substance will be useful.

The work of the Lederle Scientists (Stocksted 1954, Jukes and William 1953) had shown that many of the fungal antibiotics had growth promoting effect on poultry, ruminants and also on children. Hence, it was thought desirable to study the effect of aureomycin supplements on the growth of young fish.

Fish were kept in cement cisterns of size 120 by 100 by 70 cms. with soil substratum. Three sets were used, one control subsisting only on the natural plankton and insects, larvae, etc. a second cistern having fish to which a daily addition of groundnut cake was added and a third receiving the same amount of groundnut cake as well as aureomycin in the form of ' aurofac ', a product of Lederle laboratory containing 1·8g. of aureomycin and 1·8 mg. Vitamin–B12 per pound. After 30 days the fish were netted out, weighed and their length measured. Initial weight and size of fish were recorded.

The results of experiments are presented in Table I. The growth was calculated as per cent increment in growth i.e.,

$$\frac{\text{Weight in 30 days} \times 100}{\text{Initial weight.}}$$

The efficacy of feeding was also judged by ' food conversion ratio ' i.e., the amount of feed required to produce one Unit weight of growth in fish. The lower this ratio, the more efficacious the food. It is seen that aureomycin supplemented diet showed consistently good results. Addition of aureomycin produces more fish flesh for the same amount of good stuff such as oil seed cakes. It has got the ' food sparing ' effect i.e., smaller quantities of food could produce the same amount of growth when aureomycin is added to the rations.

The importance of growth stimulants lies in the fact that in pond fish culture, fattening of fish for the table is an important process. Likewise in raising fingerlings from fry also, there will be shortening of time by the use of aureomycin. Economy in food is also achieved.

The author wishes to thank Messrs. Lederle Laboratories Bombay, for the gift of ' aurofac ' for these experiments. The assistance of Shri M. V. Natarajan is also acknowledged.

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TABLE I.

| *Experiment number.* | *Fish used.* | *Initial size cms.* | *Percentage increase in growth for each month.* | | | *Food conversion ratio.* | |
|---|---|---|---|---|---|---|---|
| | | | *Control.* | *Groundnut cake 10·0. g.* | *Groundnut cake 10·0 g. plus 'aurofac' 1·0 g.* | *Groundnut cake.* | *Groundnut cake plus 'aurofac'.* |
| I Gourami .. .. .. | 4 Nos. | 4·7—5·2 | 7·0 | 233 | 500 | 17·1 | 8·8 |
| | | | | 15·0 g. | 15·0 g. + 1·5 g. | | |
| II Gourami .. .. .. | 4 Nos. | 4·7—5·2 | 22·0 | 62·5 | 100 | 30·0 | 16·5 |
| Tilapia .. .. .. | 6 Nos. | 7·5—11·2 | 16·0 | 88·0 | 120 | 10·5 | 16·5 |
| | | | | 12·0 g. | 12·0 g. + 1·2 g. | | |
| III Gourami .. .. .. | 5 Nos. | 6·0—10·0 | 56·0 | 67·0 | 91·0 | 9·0 | 6·6 |
| Tilapia .. .. .. | 5 Nos. | 4·8—9·5 | 22·0 | 80·0 | 85·0 | 9·0 | 7·2 |
| | | | | 10·0 g. | 10·0 g + 1· 0 g. | | |
| IV Gourami .. .. .. | 5 Nos. | 6·2—9·5 | 16·7 | 20·0 | 25·0 | 15·5 | 11·4 |
| Tilapia .. .. .. | 5 Nos. | 6·6—10·0 | 20·0 | 80·0 | 116·7 | 10·3 | 4·9 |

# A NOTE ON THE USE OF RANDIA DUMETORUM IN FISHERY MANAGEMENT

BY

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Pisciculturists would find wide application for substances that could be effectively and economically employed for the removal of unwanted fishes from Ponds and Lakes. Derris and its various formulations find wide use in fishery management.

Though a number of substances from plants like *Bassia lalifolia*, *Herium sdorum Acacia inlica* and *Randia dumetorum* are reported as toxic to fish. No systematic work has been done on the use of any of these substances. Hence an attempt was made to study in detail the toxicity of *Randia dumetorum*, to some fresh water fishes.

*Randia dumetorum* locally known as " Karaikkal " and " Madukkarai " in Tamil is available in large quantities in our forests of East Coast districts. This is commonly used for poisoning stagnant pools in the rivers for easy and wholesale illeged capture of fishes. Use of fish poisons, though prohibited by law is still in vogue to a small extent. Though it is reported that all parts of the plant could be used as fish toxicant only the seeds of *Randia dumetorum* in the powdered form were used in our experiments.

Toxicity tests were made in aquaria Jars of 15 litre capacity and in cement cisterns of 600 litres capacity. Five species of fish were used in the tests. The fishes used were *Cirrhina*, *Labeo*, *Barbus*, *Danio* and *Ophiocephalus* species, of 30 to 130 mm size. All fishes were well conditioned after capture in cement cisterns for 24 to 48 hours and only fishes in healthy condition were used as test species. After filling the containers with known quantity of water, fishes were released and after an hour known concentrations of the powder of *Randia* seeds were added and mixed well. Observations were made periodically for 24 hours. The fishes reacted in the same way as they react to derris. They moved without balance clashing against the walls of the containers often before turning upside down and dying.

The temperature during experiments ranged between 26·6° C to 28·8°C while the pH varied from 6·6 to 7·4 and in one experiment it was 8·8. Free Carbondioxide was absent at times and when present it never exceeded 4·4 p.p.m. Bicarbonate content ranged between 32 to 67 p.p.m. Sufficient concentration of dissolved oxygen was maintained till the conclusion of experiments by bubbling in oxygen when it became necessary. Appropriate controls were maintained during the experiments.

The studies made revealed that the lethal concentration to effect 100 per cent mortality in 24 hours ranged between 20 to 25 p.p.m. As *Randia dumetorum* is found in fair quantities in our forests it could be employed in fishery management. However, since the dosage required to effect a total kill is fairly high it can have only a limited use.

Author's thanks are due to Shri A. Sreenivasan, Hydrologist for advice and for guidance in the preparation of this note.

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# FISH CULTURE IN A SWAMP IN CHETPUT, MADRAS CITY.

BY

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An extensive swamp, formed by the abandonment of a former brick-making field, is located in Chetput division in Madras city. The swamp was a source of mosquito-breeding. The Department of Fisheries took charge of it and attempted fish culture with satisfactory results as briefly recounted below:

The swamp has a water-spread area of 10 acres. Its depth ranges from 1 to 10 feet at different sections. It has overgrowth of vegetation like *Hydrilla Vallisernaria* and water lilies. Frogs, water snakes, tortoises-aquatic beetles and other insects and predatory fishes like *Ophicephalus striatus, O.punctatus, Anabas testudinens, Saccobranchus fossilis, Notopterus notopterus, and Macrones, cavasius* are common. Its plankton is represented by various forms like *Oscillatoria, Botryococcus, Anabaena, Cyclotella, Tetrapedia, Scenedesmus, Merismopedia Navicula, Aphanocapsa, Chlorcoccus, Euglena, Anuraea Schizocera, Diaptomus, Cyclops, Nauplius larvae, Daphnia, Bosmina, Diaphanosoma, Brachionus and Macrothrix.*

The range of physico-chemical conditions in the swamp are as follows:—

| *Conditions.*<br>(1) | | | *Surface.*<br>(2) | *Bottom.*<br>(3) |
|---|---|---|---|---|
| Temperature, °C | .. | .. | 27.5—37.2 | 26.2—36.5 |
| Turbidity, cm. | .. | .. | 4.5—26.0 | 4.5—23.0 |
| PH | .. | .. | 6.8— 7.0 | 6.8— 7.8 |
| Dissolved oxygen, cc/1 | | .. | 1.60—4.82 | 0.70—4.63 |
| Saturation, pp 1000,000. | | | 29.0—87.0 | 12.6—78.0 |
| Free carbondioxide | | , | 0.11—0·47 | 1.11—0.55 |
| Bicarbonate | | ,, | 7.99—20.8 | 8.3—20.8 |
| Chlorides | | ,, | 5.0—15.0 | 5.0—15·0 |
| Silicates | | ,, | 0.20—1.25 | 0.22—1.25 |
| Phosphates | .. | .. | Traces | Traces |
| Nitrates | .. | .. | Nil. | Nil. |

Periodical deweeding, elimination of predators and stocking seed of cultural species, resulted in progressive fish production as shown below:

| *Year.*<br>(1) | | | *Total quantity of fish harvested in lbs.*<br>(2) | *Fish production per acre, in lbs.*<br>(3) |
|---|---|---|---|---|
| 1955–56 | .. | .. | 1552¼ | 155.2 |
| 1956–57 | .. | .. | 2132½ | 213.2 |
| 1957–58 | .. | .. | 2644 | 264.0 |
| 1958–59 | .. | .. | 5124⅛ | 512.4 |
| 1959–60 | .. | .. | 6767¾ | 676.7 |
| 1960–61 | .. | .. | 6831¼ | 683.1 |

It may be seen that the production of fish is increased from 155·2 lbs. to 683·1 lb. per acre.

The landings of 6831¼ lb. made in 1960–61 comprised of

| | | | |
|---|---|---|---|
| *Tilapia mossambica* | .. | .. | 5601¾ lbs. |
| *Catla catla* | .. | .. | 442½ |
| *Ophicephalus striatus* | .. | .. | 200½ |
| *Cirrhina reba* | .. | .. | 192½ |
| *Labeo fimbriatus* | .. | .. | 146½ |
| *Labeo rohita* | .. | .. | 111¾ |
| *Cyprinus carpio* | .. | .. | 83¼ |
| *Etroplus suratensis* | .. | .. | 30¼ |
| *Chanos chanos* | .. | .. | 8¼ |
| *Cirrhina cirrhosa* | .. | .. | 5 |
| *Notopterus notopterus* | .. | .. | 5 |
| *Mugil cephalus* | .. | .. | 4 |

About 82 per cent of the fishery is composed of *Tilapia*. It is apparent that Tilapia is suitable for culture in swampy waters containing predators like *Ophiocephalus* and *Notopterus.* The average size of Tilapia is 3–5 inches in length and 2 oz. in weight. The size attained by the other forms in the swamps ranged as follows:—

| *Name of fish.*<br>(1) | | | *Length in inches.*<br>(2) | *Weight in lbs.*<br>(3) |
|---|---|---|---|---|
| Catla | .. | .. | 12–14 | 2¼ |
| Ophiocephalus striatus | | .. | 10–24 | ½–4 |
| Labeo fimbriatus | .. | .. | 12–18 | 1–4 |
| Chanos | .. | .. | 6–9 | ¼–½ |
| Labeo rohita | .. | .. | 18–32 | 3–17½ |
| Etroplus suratensis | .. | .. | 4–6 | 8–3/16 |
| Cirrhina reba | .. | .. | 6–8 | ¼–½ |
| Mugil cephalus | .. | .. | 12–18 | 1–2 |
| Cirrhina cirrhosa | .. | .. | 12–18 | 1–4 |
| Cyprinus carpio | .. | .. | 12–26 | 3–16 |

This is a typical example of utilisation of an abandoned swamp for profitable fish culture. This fish farm has become popular among the citizens.

# SURFACE PLANKTON OF THE PEARL BANK, THOLLAYIRAM PAR, OFF TUTICORIN.

BY

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## Introduction.

The southern sector of the Gulf of Mannar off Tuticorin is rich in fisheries including those of pearl oysters and chanks. In the course of investigations on the hydrobiological conditions of this area, surface plankton from waters over the Thollayiram Par, the most productive pearl bank, was collected during the twelve months from April 1957 to March 1958. Observations on these collections are recorded in this paper. Mention may be made here of earlier work on the plankton and hydrography of the area by Chacko (1956, 1956 a, 1959), Chacko and Malu Pillay (1956, 1957), Chacko and Rajendran (1956, 1959), Chidambaram and Rajendran (1952) and Chidambaram, Rajendran and Valsan (1951).

## Materials and Methods.

The Thollayiram Par extends within the 11 to 15 miles limit (18—24 kilometres) where the depth varies from 7 to 12 fathoms (14—22 metres). Surface hauls with a standard plankton net made out of Swiss bolting silk was made at about 9 a.m. once a week throughout the year. The net was towed from a motor launch for fifteen minutes. The collections were preserved in 5 per cent formalin and brought to the laboratory and analysed qualitatively and quantitatively. The volume of the collections were standardized to 1 litre, and a sub-sample of one c.c. was employed for numerical estimation of each organism. A graduated glass plate was used for spreading the sample and examining it under a binocular microscope. The total volume of plankton sediment was estimated by settling the entire collection in a conical glass sedimenter.

## Distribution of Plankters.

Twenty important organisms were identified and studied as shown in the appended statement.

The plankton sedimentation ranged from 12 to 75 c.c. per litre. Plankton was poor from April to July and in October and December. It was abundant in August, September, November, and from July to March.

The diatoms, *Biddulphia*, *Chaetoceros*, *Coscinodiscus*, and *Rhizosolenia*, were present throughout the year except in October and February. Their total absence during these two months was noteworthy. *Biddulphia* was abundant in August and January. *Chaetoceros*, was common from June to September and *Coscinodiscus* in November. *Rhizosolenia* was swarming in September.

The blue green alga *Trichodesmium* swarmed in the area in the month of April, August and February. *Peridinium* was present in small numbers from June to September. The cystoflagellate, *Noctiluca* swarmed in September and was moderately present from October to December.

The Ctenophore, *Beroe* was abundant in April and May and was present sparsely from June to August and in December and January.

The Chaetognatha were well-represented by *Sagitta* throughout the year excepting in October. They were abundant in July, August and January. The rare and oceanic forms *Khronia* and *Spadella* were abundant in the area in the month of February and fairly common in the months of June and July. The occurrence of these rare and oceanic forms was noteworthy.

Among crustaceans, Copepods and their nauplii larvae were present throughout the year in large numbers.

The pelagic pteropod *Creseis* was abundant in August and in fair numbers in April, July, September, November, December and January.

Tunicates were represented by *Doliolum* in May, July, August and February and by *Salpa* in April only.

Eggs and larvae of fishes, particularly of *Clupeoids* and *Carangoids* were available in the plankton throughout the year.

## Summary.

Twenty important organisms occured in the plankton over the pearl bank, Thollayiram par. These showed interesting fluctuations indicating the effect of oceanic conditions on the primary productivity of this section of the sea. The presence of fish eggs and larvae proved that the area is a good nursery for pelagic fishes.

## Acknowledgments.

I am thankful to Sri P. I. Chacko, Assistant Director of Fisheries, for guidance and valuable suggestions and criticism.

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*Statement showing numerical occurrence of twenty organisms in one litre of plankton over Thollayiram par.*

| —— (1) | *April,* (2) | *May,* (3) | *June,* (4) | *July,* (5) | *August.* (6) | *September,* (7) | *October,* (8) | *November,* (9) | *December,* (10) | *January,* (11) | *February,* (12) | *March,* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. Diatomeae—* | | | | | | | | | | | | |
| 1. Biddulphia .. .. | 1,000 | .. | 6,000 | 13,000 | 28,000 | 4,000 | .. | .. | 17,500 | 50,000 | .. | 5,000 |
| 2. Chaetoceros .. .. | 1,000 | 2,500 | 20,700 | 13,000 | 16,300 | 14,000 | .. | .. | 16,000 | 5,000 | .. | 5,000 |
| 3. Coscinodiscus .. | 1,000 | 2,300 | 600 | 300 | 9,000 | 5,000 | .. | 15,000 | 1,000 | 1,000 | .. | .. |
| 4. Rhizosolenia .. .. | 2,000 | .. | 2,600 | 13,200 | 8,000 | 70,000 | | .. | .. | .. | .. | .. |
| *B. Shizophycae—* | | | | | | | | | | | | |
| 5. Trichodesmium .. | 23,000 | 12,600 | .. | .. | 36,000 | .. | .. | .. | .. | .. | .. | .. |
| *C. Protozoa—* | | | | | | | | | | | | |
| 6. Ceratium .. .. | .. | 4,300 | 2,600 | 3,600 | .. | 5,000 | 9,000 | 7,000 | 2,300 | 2,300 | .. | 600 |
| 7. Peridinium .. .. | .. | .. | 300 | 300 | 4,000 | 400 | .. | .. | .. | .. | .. | .. |
| 8. Noctiluca .. .. | .. | .. | .. | .. | .. | 13,300 | 24,500 | 28,000 | 18,500 | .. | .. | .. |
| *D. Coelenterata—* | | | | | | | | | | | | |
| 9. Diphyes .. .. | 6 | 4 | 10 | 6 | 6 | 112 | 2 | .. | .. | .. | .. | .. |
| *E. Ctenophora—* | | | | | | | | | | | | |
| 10. Beroe .. .. .. | 1,000 | 1,200 | 7 | 6 | 316 | .. | .. | .. | 50, | 52 | .. | .. |
| *F. Chaetognatha—* | | | | | | | | | | | | |
| 11. Sagitta .. .. | 29 | 38 | 69 | 554 | 389 | 171 | .. | 5 | 27 | 351 | 42 | 82 |
| 12. Khronia and Spadella, | .. | .. | 65 | 16 | .. | .. | .. | .. | | .. | 643 | .. |
| *G. Crustacea—* | | | | | | | | | | | | |
| 13. Copepods .. .. | 2,000 | 11,100 | 5,000 | 35,000 | 16,000 | 13,000 | 25,000 | 23,000 | 7,000 | 8,000 | 13,000 | 27,000 |
| 14. Nauplii .. .. | 500 | 7,000 | 1,000 | 2,500 | 2,000 | 13,000 | 4,000 | 500 | 300 | 300 | 600 | 14,000 |
| 15. Leucifer .. .. | .. | 17 | .. | 333 | .. | .. | 130 | 1,000 | 46 | 630 | 47 | 19 |
| *H. Mollusca—* | | | | | | | | | | | | |
| 16. Creseis.. .. .. | 48 | .. | .. | 49, | 7,500 | 19 | .. | 17 | 170 | 410 | .. | .. |
| *I. Tunicata—* | | | | | | | | | | | | |
| 17. Doliolum .. .. | 6 | 3 | .. | 15 | 59 | .. | .. | .. | .. | .. | 15 | .. |
| 18. Salpa .. .. .. | 16 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| *J. Pisces—* | | | | | | | | | | | | |
| 19. Fish eggs .. .. | 3 | 19 | 3 | 10 | 65 | 70 | 13 | 39 | 27 | 169 | 7 | 16 |
| 20. Fish larvae .. .. | 3 | 1 | 23 | 20 | 11 | 14 | 10 | 69 | 31 | 13 | 5 | 8 |
| Total plankton sediment (c.c.) | 13 | 14 | 12 | 16 | 60 | 48 | 17 | 75 | 12 | 45 | 71 | 75 |

# A SURVEY OF THE MARITIME METEOROLOGY AND PHYSICO-CHEMICAL CONDITIONS OF THE INDIAN PEARL BANKS OFF TUTICORIN IN THE GULF OF MANNAR FROM DECEMBER 1958 TO MAY 1959.

BY

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## Introduction.

The Indian Pearl Banks of the Central Divisions of the Gulf of Mannar lie between 8°—55′ and 8°—20′ N. Latitude and 78°-10′ and 78–25′ E Longitude, corresponding with the productive pearl bank region on the opposite Ceylon Coast. Systematic information on the meteorology and hydrography of the pearl banks are not available except some random observations (Pearson, 1902), (Chidambaram *etal*, 1949) and (Chacko and Malu Pillay 1956 and 1957). A compresensive study of the physico-chemical conditions of the Indian Pearl Banks was possible during the underwater survey of these banks by Dr. F.B. Salvodor,Food and Agricultural Organization Expert, from December 1958 to May 1959. The results of this study are presented in this paper.

## Materials and methods.

Samples of water from surface and bottom were collected from all the stations fixed by the survey team using Knudsen's reversible waterbottle. Temperature was determined with the help of Zambra and Negrette deep sea reversible thermometer of protected type. Standard apparatus were used and methods adopted for the major meteorological elements as described by Roy (1948) and for the physico-chemical conditions as detailed by Harvey (1945 and 1959)and Barnes (1957); Nitrate was estimated by the methods of Atkins (1935) using diphenyl benzdine and iron by the method of Cooper (1935) using 2:2 dipyridyl with the help of Klett Summerson Photo Electric Colorimeter, depth, nature of bottom, colour of water, visibility, current conditions of sea, temperature, specific gravity, pH, salinity, dissolved oxygen, excess base calcium, silicate–silicon, phosphate-phosphorus, nitrate—nitrogen and iron were determined and the result tabulated in Tables Nos. 1—6.

## Maritime meteorology.

The region is exposed to both the South-West and North-East monsoons. But the North-east monsoon is the chief rain-bearing one. It sets in by the middle of October or early November and takes the course of North-West east and prevaills with full vigour till the end of February or early March. The South-West monsoon sets in after a period of transition by the beginning of May and lasts up to August or early September with peak in June-July. The total precipitation during April 1958 to March 1959 was 248·0 mm. of which 59·0 mm. of precipitation was from the South-West monsoon. February experienced a total rainfall of 99·0 mm. The atmosphere is generally dry throughout, and April to October may be said to be summer period and December to February, the winter period. During the period December 1958 to May 1959, the atmospheric temperature varied between 35·0 and 25·3° C. The monthly average temperature was between 26·9° C (in February) and 30·9 ° C (in May). Basing on the monthly averages, March, April and May may be termed as the hottest months and January and February the coldest. The atmosphere was very humid during December to February and humid conditions above 80 per cent were quite common during the period. North-east wind, set in early November, with an average speed of 11·0 KM/per hour prevailed till the end of March with speed ranging up to 30·0 KM/per hour and brought a total rainfall of 25·0 mm. till the end of April. The Tambaraparani river enters the Gulf near Pinnakayal almost at the centre of the Coastal line of the parts. The Vaipar and Vembar rivers fall on the north of the area.

## Physico-chemical conditions.

The Physico-Chemical conditions of the pearl banks studied are given in Tables I to VI. The characters of each bank are as follows :—

(1) *Devi Par.*—The northern-most bank of this productive division of pearl banks lies south of Vaipar at 11.0 to 13.0 metres limit, the west and south-east regions being deeper. Bottom is flat, rocky, scattered over with fine sand. In the central and western regions sand is very little only to a height of 1 or 2 cms. but on the south-east, the sand covering is more up to 10-12 cms. On 31st January 1959, the water was green with visibility up to 10·0 metres and the current was from north to south. But in the middle of February, the water was coloured attractive blue and the visibility was reduced to 7·5 to 8·0 metres in the west and south-eastern regions although the current continued to be from north to south. Calm conditions prevailed during the entire period of study. The water was warm throughout and the surface temperature was 28·3°C on 31st January 1959 and bottom 27·6°C But in February, the surface temperature declined greatly probably due to the full away of the North-east monsoon and of the unusually high precipitation. Because of this cooling of the surface, in certain stations, surface temperature was slightly lower than the corresponding bottom temperature, the pH, was between 8·35 and 8·45 and in most of the stations, it was 8·40. Only in station SE 1 (surface), it was 8·10. The salinity was uniformly high in all the stations and was in the ascending trend. From 33·78°/oo on 31st January 1959, it rose up to 34·22/oo on 23rd February 1959. A regular vertical salinity gradient was observed in all the stations. According to Herdman (1902) pearl oyster lives in warmer and high saline water. The sudden

drop in salinity at surface in station No. SE 1 (25·27°/oo) is rather perplexing. The water was almost saturated with oxygen in January with higher concentration at the bottom. But during February, it was about 75 per cent saturated in the central northern and the western regions and still less in the other areas. The variation in excess base is suggestive of interesting biological activities at the surface as well as at the bottom. The water in the bank is generally rich in calcium and in other nutrients. Calcium concentration was normal and the Ca/Cl ratio was between 0·02194 and 0·02199 on 31st March 1959 as in the Tokyo Bay (Nisikawa, 1939). These values are comparable to those recorded by Kirk and Moberg (1933) from the English Channel, Matilda (1951) and Chow and Thomson in (1955). A sudden drop in the bottom at station N2 and a rise in the bottom at station W3 are noteworthy. Again the Ca/Cl ratio at SE 1 surface is suggestive of interesting biological phenomenon. The calcium concentration in the south-east region is very high and is far above the normal value. Values up to 0·02365 of Ca/Cl have been recorded as against the value of 0·22 of Nisikawa (1939) in Tokyo Bay. The water is very rich in silicate, phosphate, nitrate and iron and it is to be noted that the maximum concentration of silicate-silicon (14·30 gm. at /L), of phosphate-phosphorus (23·80 gm, at /L), of nitrate-nitrogen (4·25 g m. at/L) and of iron (10·2 gm. at/L) was recorded only in this bank and the surface as well as bottom waters at the "Central" station on 16th February 1959 exhibited the record concentration of phosphate, nitrate and iron. Starvation of the water for nitrate-nitrogen and iron have also been observed lately. It has been found by Venkataraman *et al* 1956 that the chemical composition of the meat of pearl oysters bearing big-sized pearls and seed-pearls and of meat of oysters without pearls are almost the same except for the iron content, being nearly 7 times in oysters without pearls than of meat with big pearls. It may be summarised that the pearl bank, Devi Par with warm and highly saline waters saturated with oxygen and very rich in essential nutrients like calcium, silicate, phosphate, nitrate and iron will serve as an ideal habitat of the Indian pearl oysters.

(2) *Pernando Par.*—It lies south of Devi Par at 11·0—11·5 metres limit. The bottom is flat, rocky with little sand in the southern region. The water is blue with a transparency of 5·0 meters. Calm conditions prevailed and only ripples were present. The current was from north to south. The water was warm and the temperature was between 27·4 and 28·0°C. The surface water was slightly cooler than the bottom at station E-2 and S-2. The pH was between 8·3 and 8·45. The salinity was high and was between 33·88 and 34·16°/oo the surface salinity being slightly higher than the bottom. The water was only 60 per cent saturated with oxygen. Calcium concentration was high and the calcium-chlorine ratio was between 0·0215 and 0·2249. The water is also rich in silicate, phosphate and nitrate. Concentration of iron was appreciable throughout. The par may be considered as a good pearl bank and is comparable to Devi Par.

(3) *Vai Par* (XV (*a*) and (*b*), dated 31st January 1959, in table II).—This is a fairly big bank lying SE of Devi par at 13·5 to 14·0 metre limit. The eastern region is slightly deeper. Bottom is rocky with sand and mud layer. In the central region bottom is sandy with nullipores, and madrepores in the eastern region. The visibility was 10·0 metres throughout. North to south current was in force. Calm conditions prevailed at sea. The water was coloured green on 31st January 1959 and was warm throughout. In the central region, the botttom was far warmer than the surface. Bottom recorded 28·9°C while the corresponding surface recorded only 27·7°C. The pH was between 8·40 and 8·45. Salinity was uniformly high between 33·87°/oo. A regular vertical salinity gradient was observed. The water was almost saturated with oxygen. The low concentration at the surface is suggestive of greater utilisation of oxygen than production by the phytoplanktons and other floral forms. The calcium concentration is slightly above normal and the Ca/Cl ratios were between 0·02197 and 0·02215 comparable to the value of 0·022 in Tokyo Bay (Nisikawa 1939). The water is also rich in silicate, phosphate, nitrate and iron. The condition of the water on this pearl bank may be considered ideal for the pearl oysters. But the sandy and muddy bottom presents a problem for the oysters to keep themselves attached.

(4) *Cruxian Par* (XIII *a*, dated 28th January 1959 in Table 2).—The par lies down south a little towards west of Devi Par at 12 metres limit with rocky bottom strewn with sand and small broken shells. The water was greenish with visibility of 10·0 metres and the southerly current was in force. Sea was a bit rough and moderate broad waves existed. The surface temperature was only 26·9°C and the bottom 27·0°C. pH was 8·5 throughout. Salinity was high but less than in the case of Devi Par and Vai Par. The water was about 80 per cent saturated with oxygen. Calcium concentration is slightly high, and the Ca/Cl ratio is comparable to the value of Nisikawa (1939) in Tokyo Bay. The water is rich in the other nutrients like silicate, phosphate, nitrate and iron. Except for a slight fall in temperature, the water may be termed as suitable for the Indian Pearl Oysters. Ca/Cl ratio is slightly less than that of Devi par.

(5) *Vantheevu Arupagum par* (XIII *b*.) dated 28th January 1959 in Table II).—Lies south-west of the Cruxian par at 12·0 metres limit. The bottom is rocky covered with sand. The water was coloured green with visibility of 10·0 metres. The surface temperature was only 27·0°C and the bottom 26·9°C and was cooler than Devi par, and Vai par, pH was between 8·45 and 8·50. Salinity was high but less than that of Devi par and Vai par. The water was about 80 per cent saturated with oxygen. Concentration of calcium was fairly high and the Ca/Cl ratio was 0·02209 on the surface and 0·0229 at the bottom. The water was rich in other nutrients like silicate, phosphate, nitrate and iron. The water of this bank compared with that of the Cruxian Par with a slightly better concentration of calcium. But the sandy bottom presents a problem.

(6) *Nagarai Par* (XIII *c*, dated 28th January 1959).—in table II This is a little south-east of Vantheevu Arupagum par at 12·5 metres limit with rocky bottom strewn with a little fine sand. The water was coloured green with a transparency of 10·0 metres. North to south current was in force. Moderate waves existed. Water was slightly warmer with temperature between 27·4°C and 27·2°C. pH ranged between 8·45 and 8·55. Salinity was 34·05°/oo at the surface and 33·4°/oo at the bottom as in the case of Cruxian par and Vantheevu Arupagum par. The water was about 77 per cent saturated with oxygen, with higher concentration of oxygen at the bottom. The

water was very rich in silicate, phosphate, nitrate, and iron. Apart from the slightly low salinity of the water, the bank might be termed as an ideal bank for pearl oysters.

(7) *Utti Par* (Station II, dated 16th December 1958) in Table I.—Lies south of Nagarai par at 13 metres limit with flat rocky bottom with or without sand. Water was blue green with a transparency of 10·0 metres. Current was from N-S and the sea was rough and waves existed. Water was slightly warmer with temperature between 27·4°C and 27·0°C. pH was between 8·45 and 8·50. Salinity was between 32·13°/oo and 32·23°/oo. The low salinity might probably be due to the influx of fresh water due to rainfall. The water was super-saturated with Oxygen. Calcium concentration was high and Ca/Cl ratio was 0·02284 at the surface and 0·2251 at the bottom. The water was fairly rich in silicate, phosphate and nitrate. There was appreciable concentration of iron also. This bank might be considered as a good pearl bank.

(8) *Athompathu Par*.—Lies south-east of Utti par at 15 metres limit. The bottom was rocky with little sand and shell grit (XII-*a*, dated 27th January 1959 in Table II). The water was greenish blue with transparency of 14·0 metres. Current was from north to south. Sea was rough with high waves. The temperature was between 27·0 and 27·1°C, the bottom water being warmer. pH was 8·40 throughout. There was high saline water both at surface (33·11°/oo) and at the bottom (33·84°/oo) with about 90 per cent saturation of oxygen and high concentration of calcium. Ca/Cl ratio was 0·02273 at surface and 0·2215 at the bottom. The water was fairly rich in other nutrients, like silicate, phosphate, nitrate and iron. The conditions existed in this bank are favourable for the Indian pearl oyster.

(9) *Pasi Par* (XII-*c*, dated 27th January 1959 in Table II).—Lies south-west of Athompathu par at 16 metres limit. Bottom was rocky with sand, spread over it. The water was greenish blue with transparency of 14·5 metre The current was from north to south. Sea was rough with waves. Water was warmer at the bottom, and temperature was between 27·1°C and 27·4°C. Bottom water was highly saline (33·84°/oo) with a saturation of about 90 per cent of oxygen. Surface salinity was much less—only 32·94°/oo. calcium-chlorine ratio was 0·02195 at the surface and 0·02190 at the bottom. The water was also rich in other nutrients like silicate, phosphate, nitrates and iron. The condition of the water was favourable for the Indian pearl oysters though the sandy bottom is a hazard.

(10) *Pathrai Par* (XIII-*b*, dated 27th January 1959 in Table II).—Lies due west of Pasi par at 15 metres limit. Bottom is flat rocky with sand over it. Greenish blue water with a transparency of 14·0 metres. Current from north to south. Sea was rough with waves. Water was fairly warm (27·2°C) with a high salinity of 33·66°/oo at the bottom and 32·90°/oo at the surface and almost saturated with oxygen. The oxygen concentration of the bottom was slightly higher. The water was found rich in calcium the calcium-chlorine ratio being 0·02251 at the surface and 0·02226 at the bottom. It was also fairly rich in silicate, phosphate, nitrate and iron. But for the sandy bottom, the bank is suitable for the Indian pearl oyster.

(11) *Tholaiyaram Par*.—The biggest and most productive bank in the group lies almost south sast of Tuticorin and on the east, north-east and south-east of Athompathu Par at 14·0–22·0 metres limit. The northern and eastern regions are deeper.

*Northern region* (Stations NWE, 10-NWE 2 and W1-E7, dated 23rd March 1959 and 24th March 1959 in Table IV).—The region is deeper on the east —23 metres while the other area is between 20 and 21 metres. Bottom is flat rocky throughout with or without a little sand spread over it. Water is bluish with a transparency between 14·5 and 16·0 metres. Current was from south-north but was very weak. Calm conditions prevailed. Water was warm and the bottom temperature invariably above 28·70/°c surface water was slightly cooler than the bottom, except at the eastern end and the central portion, where the surface temperature of the region ranged between 27·7°C and 29·4°C, pH was between 8·35 and 8·45. Salinity was uniformly high and was above 34·50°/oo throughout. The regular vertical salinity gradient was observed in all the stations, except in station No. NW 2 where high saline surface water and slightly less saline bottom water observed. The water was saturated up to 85 per cent with oxygen. The sudden variation in the excess base was suggestive of the interesting biological activities at the surface and bottom. Calcium concentration was far high and the ratio of calcium chlorine was invariably above 0·023, high calcium chlorine ratio of 0·0240 was also observed in this region. The concentration of the silicate and iron was also high. High iron content of 10·2 gm. at/L was also recorded in this region. (Station 'Central ' bottom, dated 24th March 1959 in Table IV). The water was also rich in phosphate and nitrate.

The region with its very warm and high saline water saturated with oxygen and with very high concentration of calcium and rich nutrients, is ideal for the pearl oysters.

*Northern Central* (Station B0–B5 and C1–C11, dated 26th March 1959 and 30th March 1959).—The region was also deeper on the east, 22 to 25 metres. The other portion was between 19–20 metres. The bottom was rocky throughout. But on the eastern side and the western margin, the bottom is covered with sand. In the central region a little sand with shell grit was spread over. Water was bluish with a high transparency of 16 to 18 metres. Current was from north to south on 26th and from south to north on 30th. Calm conditions prevailed generally. The water was very warm especially at the bottom and the bottom temperature was invariably above 29·0°C. The temperature of the water varies between 28·4 and 29·6°C. The bottom was warmer throughout. pH was between 8·35 and 8·45· Salinity was very high between 34·62°/oo and 34·88°/oo. A regular vertical salinity gradient was observed in all the stations. Calcium was far high and the Calcium-chlorine ratio of 0·02590 of this region is a record. The water is very rich in silicate. Concentration of phosphate, nitrate and iron was also very appreciable. The conditions existed in the bank are very ideal for the Indian pearl oysters.

*Central region* (Stations D1–D7 and E0 4–E4, F1–F7, G1–G8 H1–H8, dated 2nd April 1959, 4th April 1959 and 7th April 1959 in Table V).—The region was 17·0 to 19·5 metres deep. The eastern border was 22·0 to 22·5 metres. bottom was flat rocky with sand, the sandy layer varying between 2 to 25 c.m. in depth. Water was either greenish blue or bluish with poor transparency of 10 to 12 metres. The current was from south to north. Sea was slightly rough with waves. Water was very warm, especially at the bottom, temperature being 29·5–30·1°C. The surface was slightly less warm with a difference up to 1°C. pH was between 8·45 and 8·50 generally. The salinity was high and was between 34·28°/oo and 43·4°/oo, the salinity of the bottom being slightly higher invariably. The concentration of oxygen was a little less and saturation of oxygen varied between 60 per cent to 80 per cent. The calcium concentration was slightly less than in the northern central region. But the calcium-chlorine ratio was uniformly above the observed values of 0·022 of Nisikawa (1939). The water is very rich in silicate but the concentration of other nutrients like phosphate, nitrate and iron was very poor. The water was found to starve for nitrate and iron occasionally. But for the poverty of nutrients especially phosphate and nitrate and to some extent iron, the region may be said to be suitable for the pearl oysters, probably the poverty of nutrients will tell upon the rate of growth of the oysters. The high sandy layer on the eastern margin is not a favourable feature.

*Southern Central* (Stations 101–15, J1–J7, dated 7th April 1959 and 13th April 1959 in Table V).—The central portion of the region was in 17–18 metres limit. The eastern side was slightly deeper and a depth upto 22·5 metres was recorded at station H7. The bottom was rocky throughout with sand over it. The height of the sand layer varied up to 25 c.m. Water was greenish or blue and the transparency was poor, between 10 and 11 metres. Water was very warm especially at the bottom, being invariably above 30·0°C. Surface temperature was slightly less, ranging between 29·3 and 30·2°C, pH was between 8·35 and 8·45. Salinity was uniformly high and was between 34·22 and 34·55°/oo. The surface salinity was slightly less. The saturation of oxygen was also less and was between 60 per cent to 80 per cent. Calcium concentration was less than in the northern region and the calcium chloride ratio between 0.02173 and 0·0220. The water was rich in silicate but phosphate, nitrate and iron were very poor ; and even poverty conditions were observed very frequently. Although the water was warm and highly saline, the conditions on the bank did not appear to be favourable for the pearl oysters.

*Southern Region* (Stations K1–K10, L1–L9 and M1–M9, dated 17th April 1959 and 18th April 1959 in Table V).—The eastern portion was slightly deeper upto 20·5 metres and the other portions were between 16·0 to 18·0 metres. Bottom was rocky with up to 25 c.m. of sand. Shell grit was also found mixed with sand in certain station water was bluish and the transparency poor between 10·5 and 11·0 metres. Current was from south to north on 17th and from north to south on 18th. Swells existed. Water was very warm both at the surface and at the bottom, bottom water being slightly less warm. The temperature was between 30·4°C and 31·1°C, pH was between 8·40 and 8·50. Salinity was slightly higher than the southern central region and was between 34·40°/oo and 34·60°/oo. A regular vertical salinity gradient was observed throughout. Water was saturated up to 90 per cent with oxygen. The calcium concentration was also fair and the calcium-chlorine ratio was above 0·0220 invariably. The water was rich in nutrients in southern half ; and poverty conditions of nitrate, phosphate and iron were observed in the northern half. But for the poverty of the nutrients and the high sandy layer at the bottom, the region might be considered as a very good pearl bank.

*Koothadiar Par* (Station No. V-*a*, *b*, dated 23rd December 1958 in Table I).—This is a small bank lying at the southern end of Thollayiram par at 16·0–17·0 metres limit with flat rocky and/rocky with sand bottom. Water was bluish with 10·0 metres of transparency. The current was from north to south and the sea was rough with waves. Bottom water was warm with 27·2°C and the surface slightly cooler with temperature between 26·75°C and 26·55°C on 23rd December 1958, pH was between 8·40 and 8·50. Salinity was higher than in the Thollayiram Par region and the salinity was between 32·04 °/oo and 32·28°/oo. The water was 90 per cent saturated with oxygen. Calcium concentration was very low and the calcium-chlorine ratio was between 0·01971 and 0·02020 which is rather low then compared with normal values of Thomson and Wright (1930), Kirk and Moberg (1933), Nisikawas (1939), Syerdrup *et al* a Mitada (1951) and Chow and Thomson (1955). The water was rich in silicate, but poverty conditions of phosphate, nitrate and iron were observed. The conditions existing in the bank do not appear to be favourable for the Indian pearl oyster.

*Parkandanyan Par* (Station X-*a*, dated 20th January 1959 in Table II).—This bank lies south, west of Thollayiram Par and Koothadiar Par at 14·5 metres limit. The bottom was rocky with sand. The water was bluish with a visibility of 11·5 metres. The bottom water was moderately warm with 26·6°C and 26·3°C at the surface on 20th January 1959, pH was between 8·50 and 8·45, high salinity of 33·39 °/oo both at the surface and bottom, and the super saturation with oxygen and high concentration of calcium with calcium-chlorine ratio of 0·02245 were the other features of the water. The water was fairly rich in other nutrients like silicate, phosphate, nitrate and iron. The conditions of the bank appear to be favourable for the Indian pearl oysters.

*Nenjurichan Par* (X-*b*, dated 20th January 1959 in Table II).—This bank lies south and south-east of Parkandanyan par at 15·0 metres limit. Bottom was rocky with sand spread over. Water was bluish with a transparency of 11·5 metres. Current was from north to south Sea was rough with waves. The water was warm at the bottom having a temperature of 26·7°C. The surface temperature was 26·40°C and pH was between 8·45 and 8·50. Salinity was 33·39°/oo and the water was super saturated with oxygen. Calcium concentration was high and the calcium-chlorine ratio was 0·02245. Richness in silicate and much paucity in phosphate, nitrate and iron were the other features of the water. But for the poverty conditions of the nutrients, the bank may be taken as a good pearl bank.

*Vada Oli Pathu Par* (X–*c*, dated 20th January 1959 in Table II).—This lies at 18·0 metres with rocky bottom spread over with sand and nullipores. The water was blue with 11·5 metres of transparency. Current was from north to south. Sea was rough with waves. Bottom water was fairly warm (26·8°C) while the surface temperature was only 26·5°C, pH was between 8·45 and 8·50.

Salinity was 33·39°/oo, water was super-saturated with oxygen with a high calcium content and the calcium chlorine ratio between 0·02245 and 0·02262. Fairly rich silicate and iron content and poor phosphate and poverty and even absence of nitrate were the other features of the water. But for the poverty of nutrients, the bank may be considered as a good Pearl Bank.

*Melaompathu Par* (V–c, dated 23rd December 1958 in Table I).—This bank lies adjacent to Nenjurichan Par on the east a little towards south at 16 metres limit. Bottom was rocky covered with sand. The water was blue with 10·0 metres of transparency. The temperature of water was between 26·8°C and 27·1°C at surface and 26·5°C and 27·2°C at the bottom, pH was between 8·45 and 8·50. Salinity was between 32·35°/oo and 32·02°/oo at the surface and 31·94°/oo and 32·00°/oo at the bottom. The oxygen concentration is slightly less and water was 50·80°/oo saturated with oxygen. Calcium concentration was rather low and the calcium chlorine ratio was between 0·02014 and 0·02017. The water was very rich in silicate (11·76)/ mgm./L at surface. Either conditions of poverty or absence in respect of other nutrients like phosphate, nitrate and iron were observed.

*Melaompathu outside.*—Region is sandy with temperature of 26·7°C at surface and 27·0°C at bottom, pH between 8·45 and 8·50 and low salinity of 31·98°/oo at the surface and 31·94°/oo at the bottom. The water was about 90 per cent saturated with oxygen at the surface and 82 per cent at the bottom. Calcium chlorine ratio was very low between 0·01973 at surface and 0·02027 at the bottom. Water was rich in silicate and iron and fair in the case of phosphate and nitrate. Low salinity and oxygen and poor concentration of nutrients and calcium existing in the bank do not appear to be very favourable for pearl oysters.

*Vadaompathu Par* (VI-*a*, *b*, dated 27th December 1958 in Table I).— Lies due west and a little towards south of Parkondanyan par at 13–15 metres limit with rocky bottom with or without sand. Water was blue in colour with a transparency of 10·0 metres and fairly warm with temperature between 26·5°C and 26·7°C at the surface and 26·4°C and 26·8°C at the bottom, pH 8·50, salinity was low with 31·98°/oo at the surface and 31·89°/oo at the bottom. Water was super-saturated with oxygen at the surface but the bottom water was only 80–90 per cent saturated. Calcium chlorine ratio was between 0·01875 and 0·1945. Though rich in silicate, the water suffered poverty of phosphate and absence of nitrate. The conditions existing in the par do not appear to be favourable for the Indian pearl oyster.

*Saithmpathou par* (VI-c, dated 27th December 1958 and VII-*c*, dated 29th December 1958. in Table I).—This par lies adjacent to Vadaombathu on SE at 13–15 metres limit, with rocky bottom throughout. The water was attractive blue with transparency of 10·0 metres in the northern region and 11·0 metres in the southern region. The water is fairly warm at the bottom with temperature between 26·7°C and 27·0°C at the bottom and 26·8°C and 26·50°C at the surface; pH was between 8·50 and 8·55. Salinity was low but the northern region exhibited higher salinity 31·89 per cent to 31·98 per cent. At the southern region it was between 31·61°/oo and 31·67°/oo. Water was super saturated with oxygen in the south and almost saturated in the north calcium concentration was very poor and the calcium chlorine ratio was very low between 0·01875 and 0·01969. Northern region was fairly rich in silicate, phosphate, nitrate and iron while the southern region exhibited poverty conditions and even absence in respect of phosphate, nitrate and iron. Silicate was fairly rich. The conditions existed in the par do not appear to be favourable for the pearl oyster.

*Puli Pundu Par* (VII-*a*, *b*, dated 29th December 1959 in Table I).—This is located down south of Vadaompathu and south-west of Saithompathu par at 15 metres limit. Bottom was rocky with a little sand spread over in certain places. Water was bluish with a visibility of 11·0 metres. Current was from north to south and the sea rough with waves. The temperature was between 26·2°C and 26·5°C at the surface and 26·6°C and 26·4°C at the bottom, pH was between 8·5 and 8·55. Low salinity between31·58°/oo and31·63°/oo saturation with oxygen both at the surface and bottom and very poor concentration of calcium with Ca/Cl ratio between 0·01963 and 0·1970 were the chief factors. The water was also fairly rich in silicate and iron while nitrate and phosphate were poor. The conditions cannot be considered as suitable for the Indian pearl oysters.

*Pinnakayal Sultan Par* (VIII-*a*,dated 10th February 1959 in Table III).—Lies south–west of Pulipundu par and due east of Pinnakayal at 15 metres limit. Bottom was rocky covered with sand admixed with broken shells.

The water was greenish blue with a transparency of 10·0 metres. Current was from N-S. Calm conditions prevailed at sea.

The water was warm with temperature between 27·5°C at the surface and 27·7°C at the bottom, pH was between 8·35 and 8·40. High salinity between33·81°/oo and 33·77°/oo with super-saturation of oxygen with a low Ca/Cl ratio between 0·02020 and 0·02085 and fairly rich silicate and iron were the features of the water. Phosphate and nitrate were poor. Conditions on this bank do not appear to be very favourable for Indian pearl oyster.

*Sankuraya Pathu Par* (XVIII-*b*, dated 10th February 1959 in Table III).—Lies south-east of Pinnakayal Sultan par at 17·0 meters limit. Bottom is rocky covered with sand admixed with broken shells. Water was greenish with a transparency of 10·0 metres. Current was N-S. Sea was calm. Temperature was 27·4°C at the surface and 27·8°C at the bottom and pH between 8·40 and 8·35°/oo High salinity between 33·77°/oo at the surface and 33·83°/oo at the bottom with supersaturation of oxygen and high concentration of calcium (Ca/Cl ratio being from 0·02329 and 0·2375) fairly rich silicate and very poor phosphate, nitrate and iron were the features of the water. But for the poverty of nutrients and the sand covering of the bed, the bank may be taken as a good pearl bank.

*Rajavakku Sippi Sothitcha par* (IX-*a*, *b*. dated 17th January 1959 in Table II).—Lies down south of Pinnakayal sultan par and due west of Sankuraya Pathu at 14·0150 meters limit. Bottom was rocky throughout.

Water was bluish with a transparency of 12·5 metres. Current was from north to south and the sea was rough with waves. The temperature was between 26·7°C and 26·9°C at surface and 26·8°C and 27·0°C at the bottom on 17th January 1959, pH ranged between 8·45 and 8·50. Salinity was high and was 33·12°/oo throughout. Water was super saturated with oxygen at the surface in the northern region and almost saturated in the southern region. The concentration of oxygen at the bottom was slightly less. The calcium concentration was invariably high and the Ca/Cl ratio was above 0·0220. The very high Ca/Cl ratio of 0·02418 at the surface of the northern region is rather strange. The water was very rich in silicate and fairly rich in iron. Poverty of phosphate and nitrate were observed throughout. But for the poverty of nitrate and iron the conditions in the bed can be taken as quite suitable for the Indian pearl oyster.

*Kudamuthu Par* (VIII-*a*, *b* and *c*, dated 12th January 1959 in Table II).—Adjacent to the Rajavukku Sippi Sotichappar, it lies on the south a little towards west at 14 metres limit. The bottom was rocky throughout with sand spread over it. The sandy layer was thick in western region. The water was blue with 12·0 metres of transparency. Current was from N-S and the sea was rough with waves. The temperature was between 26·3°C and 26·6°C on 12th June 1959 bottom water being warmer, with pH between 8·45 and 8·50. Salinity was between 32·62°/oo and 32·75°/oo with super saturation of oxygen. The calcium concentration was high. The sudden drop in the calcium at the surface in the central region is sugestive of greater utilisation of calcium. The Ca/Cl ratio was between 0·02060 and 0·02382. The water was fairly rich in silicate and iron. Phosphate and nitrate were poor. But for the poverty of phosphate and nitrate the par may be termed as a very good pearl bank.

*Saithu Kudamuthu par* (IX-*c*, dated 17th January 1959).—Adjacent to the Kudamuthu par it lies on the south at 14 metres limit. The bottom was rocky. Water was blue with a transparency of 12·5 metres. Current was N-S and the sea rough with waves. The temperature was 26·9°C pH between 8·40 and 8·50 and salinity 33·12°/oo. The water was about 85 per cent saturated with oxygen. Calcium concentration was very high and the Ca/Cl ratio was between 0·02302 and 0·02344. The water was rich in silicate and fairly rich in iron, phosphate and nitrate. The conditions in the bed are suggestive that the par is a productive pearl bank.

*Kadayan par* (XVI-*a*, dated 6th February 1959.—Table III).—Lying south-east of Saithu Kudamuthu Par it is due east of Kayalpatnam, an important village between Tiruchendur and Pinnakoil, and at 14·5 metres limit. The bed was rocky with a little sand over it. The water was bluish with a transparency of 11·0 meters. Current was north to south and sea was rough with waves. The water was warm with temperature of 28·4°C at surface and 28·2°C at bottom, pH between 8·45 and 8·50, high salinity between33·89°/oo and 33·91°/oo with a high concentration of calcium with Ca/Cl ratio between 0·02281 and 0·02328 and about 70 per cent saturation of oxygen at the surface and 85 per cent at the bottom are the features of the water. Very rich silicate and fairly rich iron and poor phosphate and nitrate are the features of the nutrient contents of the water. Conditions in the bank are quite favourable for the Indian pearl oysters. But for the poverty of phosphates and nitrates, the bank can be compared with Devi par.

*Kanawa par* (XVI-*d*, dated 6th February 1959, in Table III).—Lies south and a little towards east of Kadayan par at 14·5 metres limit. The rocky bottom is covered with sand. Water was light bluish with a visibility of 11·0 metres current was north to south and sea was rough with waves. Temperature was 28·3°C at the surface and 28·2°C at the bottom, pH was between 8·45 and 8·50, high salinity between 33·88°/oo and 33·90°/oo 75·85 per cent saturation of oxygen, high concentration of calcium, very rich silicate and fairly rich iron and very poor phosphate and nitrate were the features of the water. Ca/Cl ratio was between 0·02260 and 0·02347. The condition of the bank is quite comparable with that of Kadayan par.

*Nadumalai Piditha par* (XVI-*c*. dated 6th February 1959 in Table III).—Lies down south of Kanawa par at 15·5 meters limit. The rocky bottom is covered with sand and nullipores. Water was light blue with a transparency of 11·0 metres. Current was north to South. Sea was rough with waves. The temperature was 28·5°C at the surface and 28·3°C at the bottom, pH was between 8·40 and 8·45. Salinity was high being 33·90°/oo at the surface and 33·93°/oo at the bottom. Oxygen was very low at the surface being only about 45 per cent saturation but high at bottom with a saturation of about 80 per cent. High calcium with Ca/Cl ratio between 0·02302 and 0·02371 and very rich silicate and rich iron and poor phosphate and nitrate were the features of the nutrient content of the water. The poor oxygen at the surface and rich silicate are suggestive of slow photo synthesis and dissolution of silicate from the exo-skeletons of diatoms. But for the poverty of nitrate and phosphate, the bank may be said to be a very good pearl bank.

*Karai Karuval par* (XI-*a*, dated 21st January 1959 and XIV-*a* and *b*, dated 30th January 1959 in Table II).—This is a productive par in the southern half of the division lying south of Kadayanpar and a little towards north of Tiruchendur at 15 metres limit. Flat rocky bottom with a little sand spread over in the northern region and sand, sea weeds and sponges in the central region. The water was of bluish hue with 12·0 to 14·0 metres of visibility. Current was from north to south. The bottom water was fairly warm and the temperature was between 26·5°C and 27·7°C and at the bottom 26·8 and 27·5°C, pH was between 8·40 and 8·45, high salinity between 33·39 and 34·95°/oo and up to 100 per cent saturation with oxygen and with abnormally high calcium concentration having the Ca/Cl ratio between 0·0248 and 0·02325 on 21st January 1959 and between 0·02172 and 0·02203 on 31st January 1959 and rich nutrients like silicate phosphate and nitrate and iron were the features of the water. Iron was uniformally high.

*Vilangu Karuval par.*—Lies south of Karai karuval par slightly towards the east at 15·0—18·0 metres limit. Southern and northern regions are deeper. The rocky bottom was a little sandy at the NW and NWN. Water was bluish with 12·0–14·0 meters of visibility. Southerly current and calm conditions prevailed. The bottom water was invariably warmer with a temperature difference up to 1·20°C. The temperature was between 33·39 per cent and 33·43 per cent and either 100 per cent saturation or super-saturation with oxygen, high calcium generally were the features of the water of the bank. Iron in the par was uniformly high. Low phosphate and nitrate were observed at station N2 and N 4. Similarly the oxygen was only 80·85 per cent saturation at NWN. The conditions existing in the par are very suitable for the Indian Pearl Oyster.

*Tiruchendur poonthottam par* (XVII-*a*, dated 7th February 1959 in Table III).—Lies down south little towards east of Vilangu Karuval par at 15·0 meters limit. The bottom was flat, rocky with little sand. Water was bluish with 9·0 meters of transparency. Current was north to south and sea rough with waves. Water was warm with 28·2°C at surface and 28°C at bottom, pH was between 8·35 and 8·45, high salinity between 33·87°/0 and 33·91°/0. 90–95 per cent saturation with oxygen, high calcium, silicate, fairly rich iron and poor phosphate and nitrate were the features of the water. The calcium chlorine ratio was between 0·02303 and 0·02347. The conditions of the bank appear to be quite favourable for the Indian Pearl Oyster.

*Off Manapad* (*a* and *b*., dated 6th May 1959 in Table VI).—Lies 13 miles east of Manapad point 8°—22′50″ N and 78° 19E at 19-5–20·0 meters limit. The rocky bottom with sand throughout was rich in sponges and live-corals in certain areas. Water was blue with 12·0 meters of transparency. Current was south to north. Sea was rough with high waves. Water was very warm between 30·2°C and 30·4°C, pH between 8·40 and 8·55, high salinity between 34·50°/00 and 30·57°/00 with a high saline surface and 80·0 per cent saturation with oxygen, very high calcium, rich silicate and fairly rich iron, phospate, and nitrate were the features of the water. The Calcium-chlorine ratio was between 0·02306 and 0·02342. The conditions of the bank appear to be favourable for the Indian Pearl Oyster.

## Discussions

The pearl banks of this division lie within 15·0—20·0 meters limit though certain portions of the pars were deeper. Bottom was rocky (calcite) with or without sand and sometimes admixed with shell grit. The sandy layer in certain areas were so thick as to give the impression of a sandy stratum. Nullipores, sea-weeds, sponges and madrepores were met with in Thollayiram par, Karuval par and the par off Manapad.

The water was warm and temperature up to 31·1°C has been recorded. The variation in temperature of the water was almost in consonance with the temperature of the air over lying. But due to the full sway of north-east monsoon the surface temperature of water was low, and occasionally cooler surface waters and warmer bottom waters were observed. Salinity was low in December-January and thereafter it was in the ascending trend. The low salinity during the period might probably be due to the north south current carrying cooler and less saline water from the Palk Bay. Cooler and high saline surface water and warmer and less saline bottom water observed in Kothadiar par, Vadaompathu par and in Thollaiyiram par have also been recorded by Pearson (1922) Sewell (1925) and Chacko *et al* (1954).

The water was generally saturated with oxygen. Even super-saturated water with oxygen was common. The water was generally rich in calcium and the Ca Cl ratio was above 0·022. Silicate was also uniformly rich throughout although sudden fluctuations have been observed. Silicate contents up to 14·3 gm. at /L of silicate-silicon have been observed. Phosphate and nitrate were undergoing sudden fluctuations, even poverty and conditions of starvation have also been recorded in respect of these nutrients. Although values as high as 23·2 gm. at /L phosphate-phosphorus and 4·25 gm. at /L of nitrate-nitrogen have also been observed. Iron also was undergoing sudden variation, conditions of absence as well as plenty up to 10·2 kgm. at /L having been observed. The pearl fishery of 1958–59 was a success. A total of 16,500,000 oysters with good pearl-content were fished, yielding a revenue of Rs. 8,00,000, to the Government. The main banks exploited were Tiruchendur Poonthotam par, Karuval par, Saithukudamuthu par and Kadamuthu par. A careful comparison of the conditions existing in these banks will throw light on the ideal conditions of the Indian Pearl Oyster. Rocky bottom with a little admixture of sand and shell grit spread over and warm and high saline water, fairly saturated with oxygen having a high concentration of calcium, with Ca/Cl ratio invariably above 0·0220, and fairly rich nutrients like silicate, phosphate, nitrate and Iron may be said to be quite suitable for the Indian pearl oyster. It may now be said that the conditions existing in Devi par, Fernando par, Nagarai par, Athampothu par and Thollayiram par, Parkandajan par, Rajavukku chippi Sothitcha par, Kudamathu par, Saithu Kodamuthu par and Thiruchendur Poonthottam par are quite suitable for the Indian Pearl Oyster.

## Summary.

1. The physico-chemical conditions existing in the Indian Pearl Banks of the Central division of the Gulf of Mannar from December 1958 to May 1959 were examined and discussed.

2. The warmer and high saline water with fair percentage of oxygen and high calcium chlorine ratio of the pearl banks was discussed.

3. The ideal conditions for the Indian Pearl Oysters have been brought out.

4. The promising pearl banks have been indicated.

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TABLE 1—*Showing physico-chemical conditions of Pearl*

| *Station number.* | *Surface or bottom.* | *Colour.* | *Depth (metres).* | *Nature of bottom.* | *Visibility. (metres).* | *Current.* | *Sea or swell.* |
|---|---|---|---|---|---|---|---|
| *10th December 1958 Thollayiram par (Central)—* | | | | | | | |
| *I a* | Bottom | Fine bluish Green. | 19·0 | Rocky with sand | 10·5 | N—S | Sea high ways |
| *b* | Do. | Do. | 19·0 | Do. | 11·0 | N—S | Do. |
| *16th December 1958 Karai par (Utti par)—* | | | | | | | |
| II *a* | Surface | Bluish green. | 13·0 | Flat rocky with sand. | 10·0 | N—S | Sea highways |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *19th December 1958 Thollayiram par (Northern region)—* | | | | | | | |
| III *a* | Surface<br>Bottom | Fine Blue | 17·8 | Rocky with sand and Nellipore. | 11·0 | N—S | Sea highways |
| *b* | Surface<br>Bottom | Do. | 19·8 | Sandy | 11·0 | N—S | Do. |
| *c* | Surface<br>Bottom | Do. | 15·0 | Rocky with sand and Nellipore. | 11·0 | N—S | Do. |
| *d* | Surface<br>Bottom | Do. | 18·0 | Do. | 11·5 | N—S | Do. |
| *e* | Surface<br>Bottom | Do. | 17·5 | Do. | 11·5 | N—S | Do. |
| *23rd December 1958 Kuthadiar Par—* | | | | | | | |
| V *a* | Surface | Blue | 17·0 | Rocky | 10·0 | N—S | Sea waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *b* | Surface | Do. | 16·0 | Sandy | 10·0 | N—S | Do. |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Melaombathu Par—* | | | | | | | |
| *c* | Surface | Blue | 16·0 | Rocky | 10·0 | N—S | Sea waves |
| | Bottom | .. | .. | .. | .. | .. | .... |
| *d* | Surface | Do. | 16·0 | Sandy | 10·0 | N—S | Do. |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Outside Melaombathu par—* | | | | | | | |
| *e* | Surface | Blue | 18·0 | Sandy | 10·0 | N—S | Sea waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *27th December 1958 Vadaombathu par—* | | | | | | | |
| VI *a* | Surface | Blue | 13·0 | Rocky | 10·0 | N—S | Sea waves |
| | Bottom | .. | .. | .... | .. | .. | .. |
| *b* | Surface | Do. | 15·0 | Rocky with sand | 10·0 | N—S | Do. |
| | Bottom | .. | | .... | .. | .. | .... |
| *Saithombathu Par (North)—* | | | | | | | |
| *c* | Surface | Attractive blue. | 13·0 | Rocky | 10·0 | N—S | Do. |
| | Bottom | | | .... | .. | .. | .... |
| *29th December 1958 Pulipoondu par —* | | | | | | | |
| VII *a* | Surface | Blue | 15·0 | Rocky with sand | 11·0 | N—S | Sea high waves |
| | Bottom | | .. | .... | .. | .. | .... |
| *b* | Surface | Do. | 15·0 | Rocky | 11·0 | N—S | Do. |
| | Bottom | | | .... | .. | .. | .... |
| *Saithombathu par (South)—* | | | | | | | |
| *c* | Surface<br>Bottom | Blue | 15·0 | Rocky | 11·0 | N—S | Do. |

*Banks off Tuticorin during December* 1958.

| *Temp.* °*C.* | *Sp. gr.* | *pH.* | *S°/oo.* | *Dissolved* $O_2$ *ml/L.* | *Excess base mg/L.* | *Calcium Mgm./L* | *Silicate Mgm. /L* | $PO_4$*—P Mgm. /L* | $NO_3$*—N Mgm. /L* | *Iron Mgm. /L* | *Remarks.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 26·9 | 21·3 | 8·35 | 32·28 | 5·25 | 75·00 | 9,658 | 0·87 | 0·80 | 1·20 | 0·30 | .. |
| 26·8 | 21·3 | 8·50 | 32·30 | 5·15 | 81·00 | 9,863 | 1·12 | 0·42 | 0·80 | .. | .. |
| 27·4 | 21·3 | 8·50 | 32·14 | 5·14 | 66·00 | 10,160 | 1·00 | 0·95 | 1·00 | 0·25 | .. |
| 27·0 | 21·4 | 8·45 | 32·23 | 5·07 | 69·00 | 10,040 | 1·35 | 0·95 | 0·80 | 0·40 | .. |
| 27·5 | 21·0 | 8·40 | 31·33 | 4·38 | 79·50 | 9,190 | 0·71 | 0·08 | 0·10 | 0·10 | .. |
| 27·3 | 21·1 | 8·45 | 31·74 | 5·07 | 76·50 | 9,350 | 0·90 | 0·20 | 0·45 | 0·40 | .. |
| 27·5 | 21·0 | 8·40 | 31·38 | 4·25 | 75·00 | 9,270 | 1·12 | 0·38 | 0·75 | .. | Outside the par. |
| 27·46 | 21·1 | 8·40 | 31·70 | 4·32 | 81·00 | 9,350 | 0·90 | 1·65 | 2·85 | 0·35 | |
| 27·6 | 21·0 | 8·45 | 31·38 | 4·40 | 75·00 | 9,150 | 1·34 | 0·80 | 0·90 | 0·50 | |
| 27·4 | 21·2 | 8·45 | 31·74 | 4·48 | 76·20 | 10,000 | 5·70 | 0·40 | 0·40 | 0·32 | .. |
| 27·6 | 21·0 | 8·45 | 31·38 | 4·40 | 76·80 | 9,150 | 1·03 | 0·30 | 0·40 | 0·10 | .. |
| 27·5 | 21·1 | 8·45 | 31·70 | 4·25 | 79·80 | 9,350 | 1·34 | 0·30 | 0·40 | 1·60 | .. |
| 27·7 | 21·0 | 8·40 | 31·30 | 4·30 | 75·00 | 9,190 | 1·04 | 0·20 | .. | 0·35 | .. |
| 27·5 | 21·1 | 8·40 | 31·65 | 4·52 | 79·80 | 9,400 | 1·45 | 0·10 | 0·08 | 1·80 | .. |
| 26·75 | 21·3 | 8·45 | 32·28 | 4·25 | 78·00 | 9,030 | 1·25 | 0·10 | 0·10 | 0·35 | .. |
| 27·20 | 21·2 | 8·40 | 32·23 | 4·03 | 81·00 | 8,950 | 2·14 | 0·28 | 0·30 | 0·40 | .. |
| 26·55 | 21·0 | 8·50 | 32·04 | 3·84 | 81·00 | 8,740 | 1·60 | 0·15 | .. | 0·20 | .. |
| 27· 2 | 21·2 | 8·50 | 32·15 | 4·11 | 79·80 | 9,190 | 7·48 | 0·25 | 0·30 | 0·40 | .. |
| 26·80 | 21·3 | 8·45 | 32·33 | 3·97 | 81·00 | 9,030 | 11·76 | 0·08 | .. | .. | .. |
| 26·50 | 21·0 | 8·90 | 31·94 | 3·81 | 81·00 | 8,950 | 1·60 | 0·25 | 0·30 | 0·50 | .. |
| 27·1 | 21·2 | 8·45 | 32·12 | 2·47 | 79·50 | 8,950 | 0·60 | 0·10 | .. | 0·20 | .. |
| 27·2 | 21·2 | 8·50 | 32·00 | 3·25 | 79·50 | 8,950 | 1·80 | 0·36 | 0·40 | 0·50 | .. |
| 26·7 | 21·2 | 8·45 | 31·98 | 4·45 | 79·80 | 8,740 | 1·32 | 0·30 | 0·40 | 1·00 | .. |
| 27·0 | 21·2 | 8·50 | 31·94 | 4·00 | 81·00 | 8,950 | 1·85 | 0·72 | 1·00 | 1·80 | .. |
| 26·50 | 21·3 | 8·50 | 31·98 | 5·00 | 80·10 | 8,540 | 0·78 | 0·08 | .. | .. | .. |
| 26·4 | 21·3 | 8·50 | 31·89 | 4·18 | 78·00 | 8,340 | 4·70 | 0·10 | .. | 0·15 | .. |
| 26·70 | 21·3 | 8·50 | 31·98 | 5·07 | 78·60 | 8,540 | 1·11 | 0·20 | 0·30 | 0·28 | .. |
| 26·80 | 21·3 | 8·45 | 31·89 | 4·32 | 77·10 | 8,580 | 1·17 | 0·35 | 0·50 | 1·50 | .. |
| 26·8 | 21·3 | 8·50 | 31·98 | 4·52 | 80·00 | 8,540 | 0·71 | 0·75 | 0·80 | 2·50 | .. |
| 26·7 | 21·3 | 8·50 | 31·89 | 4·38 | 78·00 | 8,580 | 1·50 | 0·85 | 0·85 | 2·50 | .. |
| 26·2 | 21·4 | 8·55 | 31·63 | 4·73 | 84·00 | 8,620 | 1·01 | 0·20 | 0·20 | 1·00 | .. |
| 26·6 | 21·3 | 8·50 | 31·63 | 5·20 | 84·00 | 8,580 | 8·91 | 0·35 | 0·40 | 1·50 | .. |
| 26·5 | 21·3 | 8·50 | 31·58 | 5·00 | 82·80 | 8,580 | 1·19 | 0·15 | 0·10 | 0·80 | .. |
| 26·4 | 21·3 | 8·50 | 31·58 | 4·66 | 82·80 | 8,580 | 2·99 | 0·45 | 0·50 | 0·95 | .. |
| 26·5 | 21·3 | 8·55 | 31·61 | 5·27 | 81·60 | 8,400 | 0·82 | 0·30 | 0·10 | 0·10 | .. |
| 27·0 | 21·2 | 8·50 | 31·67 | 5·00 | 82·60 | 8,640 | 1·07 | 0·20 | .. | .. | .. |

## TABLE 2—*Showing physico-chemical conditions of Pearl*

| *Station number.* | *Surface or bottom.* | *Colour.* | *Depth (metres).* | *Nature of bottom.* | *Visibility. (metres).* | *Current.* | *Sea or swell.* |
|---|---|---|---|---|---|---|---|
| *12th January 1959 Kudumuthu Par (North)—* | | | | | | | |
| VIII *a* | Surface | Blue | 14·0 | Sandy | 12·0 | N—S | Sea high waves |
| | Bottom | | .. | .... | .. | .. | .... |
| *b* | Surface | Blue | 14·0 | Rocky with sand | 12·0 | N—S | Sea high waves |
| | Bottom | | .. | .... | .. | .. | .... |
| *c* | Surface | Blue | 14·0 | Rocky white | 12·0 | N—S | Sea high waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *17th January 1959 Rajavucku Chippi Sothitcha Par—* | | | | | | | |
| IX *a* | Surface | Blue | 15·0 | Rocky | 12·5 | N—S | Sea waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *b* | Surface | Blue | 14·0 | Rocky | 12·5 | N—S | Sea waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Saith Kudamuthu Bar—* | | | | | | | |
| *c* | Surface | Blue | 14·0 | Rocky | 12·5 | N—S | Sea waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *20th January 1959 Parkudainthan Par—* | | | | | | | |
| X *a* | Surface | Blue | 14·5 | Rocky with sand | 11·5 | N—S | Sea small waves. |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Nenjurithan Par—* | | | | | | | |
| *b* | Surface | Blue | 15·0 | Rocky and sand | 11·5 | N—S | Sea small waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Vadaolippathu Par—* | | | | | | | |
| *c* | Surface | Blue | 18·0 | Rocky with Nullipore and sand. | 11·5 | N—S | Sea small waves. |
| | Bottom | .. | .. | | .. | .. | .... |
| *21st January 1959 Karai Karuval Par—* | | | | | | | |
| XI *a* | Surface | Blue | 15·0 | Rocky | 14·0 | N—S | Swell |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Vilangu Karuval Par—* | | | | | | | |
| *b* | Surface | Blue | 15·0 | Rocky | 14·0 | N—S | Swell |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *27th January 1959 Athuompathu Par—* | | | | | | | |
| XII *a* | Surface | Greenish Blue | 15·0 | Sand with broken shells. | 14·0 | N—S | Waves |
| | Bottom | | | | .. | .. | .... |
| *Patharai Par—* | | | | | | | |
| *b c* | Surface | Greenish Blue. | 15·0 | Sand over Flat rock | 14·0 | N—S | Waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Pasi Par—* | | | | | | | |
| *d* | Surface | Greenish Blue | 16·0 | Sandy | 14·5 | N—S | Waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *28th January 1959 Cruxian Par—* | | | | | | | |
| XIII *a* | Surface | Green | 12·0 | Small broken shells and sand over rocks. | 10·0 | N—S | Waves |
| | Bottom | .. | .. | | | | |
| *Vantheevu Arupagum Par—* | | | | | | | |
| *b* | Surface | Green | 12·0 | Sandy | 10·0 | N—S | Waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *Nagarai Par—* | | | | | | | |
| *d* | Surface | Green | 12·5 | Rocky with little sand. | 10·0 | N—S | Waves |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *30th January 1959 Vilangu Karuval Par (North Karuval)—* | | | | | | | |
| XIV *a* | Surface | Blue | 15·0 | Flat rocky with sand weeds and sponges. | 12·0 | N—S | Swell |
| | Bottom | .. | .. | | .. | | .... |
| *c* | Surface | Blue | 15·0 | Flat Rocky with sand. | 12·0 | N—S | Swell |
| | Bottom | .. | .. | .... | .. | .. | .... |
| *31st January 1959 Vaipar—* | | | | | | | |
| XV *a* | Surface | Green | 13·5 | Sandy with mud layyer. | 10·0 | N—S | Ripple |
| | Bottom | .. | .. | | .. | | .... |
| *b* | Surface | Green | 14·0 | Sandy with mud and Nullipore and Madripore and rocky below ¼ to ½ meter. | 10·0 | N—S | Ripple |
| | Bottom | .. | .. | | .. | .. | .. |
| *Devi Par—* | | | | | | | |
| *c* | Surface | Green | 11·0 | Rocky | 10·0 | N—S | Ripple |
| | Bottom | .. | .. | .... | .. | .. | .... |

*Banks off Tuticorin during January* 1959.

| *Temp,* °*C.* | *Sp gr.* | *pH.* | *S°/oo.* | *Dissolved* $O_2$ *ml/L.* | *Excess base m/L.* | *Calcium Mgm. /L.* | *Silicate Mgm. /L.* | $PO_4$*—P Mgm. /L.* | $NO_3$*—N Mgm. /L.* | *Iron Mgm /L.* | *Remarks.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 26·3 | 21·9 | 8·45 | 32·62 | 5·45 | 70·18 | 10,370 | 0·98 | 0·20 | 0·21 | 0·35 | West. |
| 26·5 | 21·9 | 8·45 | 32·67 | 4·90 | 70·18 | 10,370 | 0·98 | 0·32 | 0·25 | 0·40 | .. |
| 26·6 | 21·9 | 8·50 | 32·67 | 5·11 | 70·69 | 9,354 | 1.07 | 0·18 | .. | 0·25 | Central. |
| 26·6 | 21·9 | 8·50 | 32·75 | 5·18 | 69·39 | 10,580 | 1·21 | 0·30 | 0·20 | 0·70 | .. |
| 26·6 | 21·9 | 8·45 | 32·67 | 5·18 | 71·47 | 10,580 | 0·98 | 0·10 | .. | 0·40 | East. |
| 26·6 | 21·9 | 8·50 | 32·67 | 5·18 | 71·47 | 10,770 | 1·25 | 0·10 | .. | 0·25 | .. |
| 26·7 | 22·0 | 8·45 | 33·21 | 5·04 | 72·78 | 10,870 | 1·65 | 0·30 | 0·22 | 0·70 | North |
| 26·8 | 22·0 | 8·45 | 33·21 | 4·49 | 71·49 | 10,370 | 3·21 | 0·35 | 0·20 | 0·60 | .. |
| 26·9 | 22·0 | 8·50 | 33·21 | 4·56 | 70·18 | 10,450 | 1·80 | 0·20 | 0·18 | 0·85 | South. |
| 27·0 | 22·0 | 8·50 | 33·21 | 4·43 | 70·18 | 10,370 | 3·56 | 0·35 | 0·45 | 0·90 | .. |
| 26·9 | 22·0 | 8·40 | 33·21 | 4·04 | 71·47 | 10,770 | 1·60 | 0·25 | 0·30 | 0·50 | West. |
| 26·9 | 22·0 | 8·50 | 33·21 | 3·97 | 72·78 | 10,580 | 1·78 | 0·40 | 0·28 | 0·75 | .. |
| 26·3 | 22·2 | 7·50 | 33·39 | 4·90 | 70·18 | 10,370 | 1·16 | 0·45 | 0·50 | 1·00 | Central. |
| 26·6 | 22·1 | 8·45 | 33·39 | 4·63 | 68·87 | 10,250 | 0·89 | 0·45 | 0·60 | 0·92 | .. |
| 26·4 | 22·1 | 8·45 | 33·39 | 4·97 | 70·18 | 10,370 | 1·34 | 0·25 | 0·20 | 0·35 | Central. |
| 26·7 | 22·0 | 8·50 | 33·29 | 4·97 | 70·18 | 10,330 | 1·17 | 0·40 | 0·30 | 0·50 | Central. |
| 26·5 | 22·1 | 8·45 | 33·29 | 4·83 | 70·18 | 10,450 | 0·98 | 0·10 | .. | 0·80 | Central. |
| 26·8 | 22·0 | 8·50 | 33·39 | 5·00 | 68·87 | 10,370 | 1·07 | 0·18 | .. | 0·20 | .. |
| 26·5 | 22·1 | 8·40 | 33·39 | 4·90 | 72·00 | 10,740 | 0·71 | 0·90 | 0·95 | 2·00 | Contral. |
| 26·8 | 22·0 | 8·45 | 33·39 | 5·45 | 72·00 | 11,190 | 0·62 | 0·82 | 1·00 | 3·50 | .. |
| 26·5 | 22·1 | 8·40 | 33·39 | 4·80 | 71·40 | 10,700 | 1·03 | 0·75 | 0·95 | 2·14 | Central. |
| 26·8 | 22·0 | 8·40 | 33·39 | 4·90 | 70·50 | 10,700 | 0·96 | 0·82 | 1·10 | 4·02 | .. |
| 27·0 | 21·7 | 8·40 | 33·11 | 5·42 | 71·00 | 10,410 | 1·00 | 0·85 | 0·88 | 1·00 | South. |
| 27·1 | 22·0 | 8·40 | 33·84 | 4·70 | 70·50 | 10,370 | 1·10 | 0·96 | 1·00 | 1·50 | .. |
| 27·2 | 22·0 | 8·50 | 32·90 | 4.12 | 70·50 | 10,250 | 0·96 | 0·72 | 0·80 | 0·10 | Central. |
| 27·2 | 21·9 | 8·45 | 33·66 | 4·52 | 70·50 | 10,370 | 0·85 | 0·90 | 0·80 | 1·10 | .. |
| 27·1 | 21·5 | 8·50 | 32·94 | 4·25 | 70·50 | 10,000 | 1·10 | 1·00 | 1·10 | 2·50 | West. |
| 27·4 | 22·0 | 8·40 | 33·84 | 4·35 | 69·60 | 10,250 | 1·50 | 1·25 | 1·30 | 4·00 | .. |
| 26·9 | 21·6 | 8·50 | 33·01 | 4·15 | 70·50 | 10,000 | 0·95 | 0·95 | 1·00 | 1·85 | Central. |
| 27·0 | 21·8 | 8·50 | 33·04 | 4·15 | 69·90 | 10,250 | 1·25 | 0·95 | 1·00 | 3·50 | .. |
| 27·0 | 21·6 | 8·50 | 33·05 | 4·00 | 70·50 | 10,100 | 1·00 | 1·17 | 0·70 | 1·50 | East. |
| 26·9 | 21·8 | 8·45 | 33·00 | 4·04 | 70·50 | 10,300 | 1·45 | 2·00 | 1·70 | 1·75 | .. |
| 27·4 | 21·6 | 8·55 | 33·05 | 3·75 | 70·50 | 10,200 | 1·50 | 1·25 | 1·30 | 2·00 | Central. |
| 27·2 | 21·8 | 8·45 | 33·42 | 4·00 | 69·60 | 10,320 | 2·10 | 1·75 | 2·15 | 4·50 | .. |
| 27·5 | 22·0 | 8·40 | 33·85 | 4·00 | 70·50 | 10,220 | 1·85 | 0·90 | 1·00 | 1·85 | Central. |
| 27·5 | 22·0 | 8·45 | 33·92 | 3·45 | 69·00 | 10,300 | 2·50 | 0·85 | 0·50 | 3·70 | .. |
| 27·7 | 22·0 | 8·40 | 33·88 | 4·14 | 69·60 | 10,300 | 2·00 | 0·85 | 1·05 | 1·55 | North. |
| 27·5 | 22·0 | 8·45 | 34·95 | 4·14 | 69·60 | 10,350 | 2·50 | 0·90 | 0·75 | 3·50 | .. |
| 27·7 | 22·0 | 8·45 | 33·85 | 4·07 | 67·80 | 10,300 | 1·32 | 1·00 | 0·85 | 1·25 | Central. |
| 28·9 | 21·6 | 8·40 | 33·94 | 4·62 | 67·80 | 10,400 | 1·58 | 1·15 | 1·10 | 3·25 | .. |
| 27·9 | 22·0 | 8·45 | 33·90 | 4·21 | 67·50 | 10,300 | 1·25 | 1·05 | 1·00 | 1·50 | East. |
| 27·6 | 22·0 | 8·40 | 33·94 | 4·21 | 67·80 | 10,400 | 1·50 | 1·25 | 1·35 | 3·50 | .. |
| 28·3 | 21·6 | 8·45 | 33,78 | 4·15 | 67·50 | 10,250 | 1·50 | 1·10 | 1·00 | 2·50 | Central. |
| 27·6 | 22·0 | 8·40 | 33·85 | 4·39 | 69·00 | 10,300 | 2·50 | 1·25 | 1·50 | 4·00 | |

TABLE 3.—*Showing physico-chemical conditions of Pear*

| *Station number.* | *Surface or bottom.* | *Colour.* | *Depth (metres).* | *Nature or bottom.* | *Visibility. (metres).* | *Current.* | *Sea or swell.* |
|---|---|---|---|---|---|---|---|
| *6th February* 1959 *Kadayan Par*— | | | | | | | |
| XVI *a* | Surface | Blue | 14·5 | Rocky with slight sand (3 cm.) | 11·0 | N—S | Sea high waves |
| | Bottom | .. | | | | | |
| *Kanava Par*— | | .. | | | | | |
| *b* | Surface | Slight | 14·5 | Sandy | 11·0 | N—S | Do. |
| | Bottom | Bule | .. | | | .. | .. |
| *Nadumalai Peditha Par*— | | | | | | | |
| *c* | Surface | Slight | 15·5 | Sand over rock | 11·0 | N—S | Sea high waves |
| | Bottom | Blue | .. | .. | .. | .. | .. |
| *7th February* 1959 *Thiruchendur Poonthondam Par*— | | | | | | | |
| XVII *a* | Surface | Blue | 15·0 | Flat rock with sand | 9·0 | N—S | Sea high waves |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *10th February* 1959 *Pinnakayal Sulthan Par*— | | | | | | | |
| XVIII *a* | Surface | Greenish | 15·0 | Sandy with broken shell. | 10·0 | N—S | Swell |
| | Bottom | Blue | .. | .. | .. | .. | .. |
| *Sanguraya Pathu Par*— | | | | | | | |
| *o* | Surface | Greenish | 17·0 | Do. | 10·0 | N—S | Swell |
| | Bottom | Blue | .. | .. | .. | .. | .. |
| *16th February* 1959 *Devi Par*— | | | | | | | |
| Central | Surface | Attractive blue | 11·55 | Flat rock with 2 cm. of sand. | 10·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| N2 | Surface | Attractive blue | 12·0 | Flat rock and sand | 10·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| n4 | Surface | Attractive blue | 11·5 | Flat rock with 5 cm. of sand. | 10·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *18th February* 1959 *Devi Par*— | | | | | | | |
| W1 | Surface | Attractive blue | 11·0 | Rock with 2 cm. of sand. | 8·0 | N—S | Swell |
| | Bottom | .. | | .. | .. | .. | .. |
| W2 | Surface | Attractive blue | 12·0 | Do. | 8·6 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| W3 | Surface | Attractive blue | 12·0 | Rock with 8 cm, of sand, | 8·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *20th February* 1959 *Devi Par*— | | | | | | | |
| SE1 | Surface | Attractive blue | 11·0 | Rock with little sand. | 7·5 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| SE2 | Surface | Attractive blue | 13·0 | Sandy (10 to 12 cm,). | 7·5 | N—S | Ripples |
| | Bottom | .. | .. | Sand. | .. | .. | .. |
| SE3 | Surface | Attractive blue | 13·0 | Sandy | 7·5 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| 23rd *February* 1959 *Devi Par*— | | | | | | | |
| | Surface | Attractive blue | 11·5 | Flat rock with little sand. | 8·0 | N—S | Ripples |
| | Bottom | .. | .. | | .. | .. | .. |
| | Surface | Attractive blue | 11·0 | Do. | 8·0 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | . |
| | Surface | Attractive blue | 11·5 | Do, | 8·0 | N—S | Ripples |
| | Bottom | | .. | .. | .. | .. | |
| *25th February* 1959 *Fernando Par*— | | | | | | | |
| W2 | Surface | Blue | 10·5 | Flat rock | 8·0 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| E2 | Surface | Blue | 11·5 | Flat rock | 8·0 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| S2 | Surface | Blue | 11·0 | Flat rock with little sand. | 8·0 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |

*Banks off Tuticorin during February* 1959.

| *Temp* °*C* | *Sp. gr.* | *pH.* | *S°/oo.* | *Dissolved* $O_2$ *ml/L.* | *Excess base mg./L.* | *Calcium Mgm./L.* | *Silicate Mgm./L.* | $PO_4$—*P Mgm./L.* | $NO_3$—*N Mgm./L.* | *Iron Mgm./L* | *Remarks.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28·4 | 21·5 | 8·50 | 33·89 | 3·10 | 83·54 | 10,700 | 2·45 | 0·10 | .. | 0·90 | |
| 28·2 | 21·5 | 8·45 | 33·91 | 3·86 | 89·28 | 10,920 | 2·14 | 0·25 | 0·30 | 0·85 | |
| 28·3 | 21·5 | 8·50 | 33·88 | 3·59 | 89·28 | 10,600 | 2·76 | 0·10 | .. | 0·90 | |
| 28·2 | 21·5 | 8·45 | 33·90 | 4·00 | 89·28 | 11,000 | 0·85 | 0·15 | 0·25 | 0·90 | |
| 28·5 | 21·5 | 8·45 | 33·90 | 2·00 | 87·36 | 10,800 | 3·56 | 0·05 | 0·07 | 0·90 | |
| 28·3 | 21·5 | 8·40 | 33·93 | 3·76 | 87·36 | 11,120 | 2·21 | 0·10 | 0·25 | 1·00 | |
| 28·2 | 21·3 | 8·35 | 33·87 | 4·42 | 89·28 | 10,800 | 2·14 | 0·18 | 0·05 | 0·85 | |
| 28·0 | 21·3 | 8·45 | 33·91 | 4·55 | 78·36 | 11,000 | 2·00 | 0·10 | 0·10 | 0·92 | |
| 27·5 | 21·3 | 8·40 | 33·77 | 5·52 | 67·61 | 10,920 | 0·70 | 0·25 | 0·18 | 1·00 | Outside the par. |
| 27·7 | 21·3 | 8·35 | 33·81 | 4·90 | 75·87 | 10,600 | 1·36 | 0·45 | 0·50 | 3·30 | |
| 27·4 | 21·3 | 8·40 | 33·77 | 5·72 | 70·28 | 10,880 | 0·70 | 0·08 | 0·10 | .. | |
| 27·8 | 21·5 | 8·30 | 33·83 | 5·24 | 64·33 | 11,120 | 1·28 | 0·10 | 0·15 | 0·25 | Outside the par. |
| .. | 22·5 | 8·45 | 33·85 | 3·38 | 65·00 | 10,000 | 0·70 | 23·80 | 3·40 | 10·20 | |
| .. | 21·5 | 8·40 | 33·94 | 2·95 | 64·33 | 10,200 | 1·36 | 4·20 | 4·25 | 10·20 | |
| .. | 21·3 | 8·45 | 33·79 | 3·58 | 65·00 | 10,000 | 0·70 | 23·80 | 3·10 | 8·50 | |
| .. | 21·5 | 8·40 | 33·90 | 3·04 | 67·75 | 9,356 | 2·30 | 1·12 | 4·20 | 9·00 | |
| .. | 21·3 | 8·45 | 33·70 | 3·25 | 67·80 | 9,922 | 3·00 | 2·80 | 3·10 | 7·80 | |
| .. | 21·5 | 8·40 | 33·94 | 2·90 | 64·33 | 10,280 | 2·10 | 2·80 | 4·00 | 9·00 | |
| 27·8 | 21·8 | 8·40 | 33·98 | 3·72 | 64·75 | 10,400 | 1·25 | 0·70 | .. | 0·58 | |
| 27·9 | 21·8 | 8·35 | 34·03 | 4·14 | 65·75 | 10,200 | 2·32 | 1·12 | 1·07 | 1·35 | |
| 27·8 | 21·8 | 8·40 | 33·93 | 3·92 | 65·75 | 10,140 | 1·70 | 1·40 | 0·05 | .. | |
| 28·0 | 21·8 | 8·40 | 34·03 | 3·93 | 64·75 | 10,400 | 1·43 | 1·12 | 0·05 | 1·08 | |
| 27·9 | 21·8 | 8·35 | 33·93 | 3·52 | 66·75 | 10,200 | 2·70 | 1·12 | 1·00 | 0·70 | |
| 27·7 | 21·8 | 8·35 | 33·98 | 4·69 | 67·00 | 10,520 | 3·14 | 1·40 | 1·10 | 1·25 | |
| 27·9 | 20·0 | 8·10 | 25·27 | 2·75 | 78·00 | 8,400 | 14·30 | 1·40 | 3·40 | 2·56 | |
| 27·4 | 22·0 | 8·40 | 34·09 | 1·52 | 70·28 | 10,800 | 1·60 | 1·13 | 0·25 | 1·34 | |
| 27·9 | 22·0 | 8·35 | 33·98 | 2·48 | 70·28 | 10,520 | 4·60 | 1·69 | 0·89 | 0·40 | |
| 27·6 | 21·8 | 8·40 | 33·99 | 2·35 | 70·28 | 10,920 | 2·00 | 1·40 | .. | 2·15 | |
| 27·6 | 22·0 | 8·40 | 33·01 | 3·74 | 71·45 | 10,800 | 0·72 | 14·08 | 0·71 | 1·34 | |
| 27·8 | 22·0 | 8·35 | 34·10 | 3·54 | 71·45 | 10,800 | 1·43 | 0·70 | .. | 3·00 | |
| 27·7 | 22·2 | 8·40 | 34·22 | 2·69 | 72·30 | 10,720 | 1·25 | 0·70 | 0·75 | 1·05 | |
| 27·7 | 22·2 | 8·45 | 34·16 | 3·04 | 75·25 | 10,400 | 2·70 | 1·12 | 0·80 | 2·10 | |
| 27·8 | | | | | No sample. | | | | | | |
| 28·0 | 22·2 | 8·40 | 34·22 | 3·73 | 71·75 | 10,880 | 0·90 | 0·70 | 0·80 | 0·85 | |
| 27·4 | 22·2 | 8·40 | 34·22 | 2·89 | 76·00 | 10,000 | 1·25 | 1·40 | 1·72 | 1·90 | |
| 27·2 | 22·2 | 8·45 | 34·22 | 4·00 | 70·50 | 11,200 | 0·90 | 8·20 | 5·80 | 9·50 | |
| 27·8 | 22·0 | 8·40 | 34·01 | 2·76 | 75·25 | 10,800 | 6·10 | 0·70 | 0·95 | 0·45 | |
| 25·5 | 21·8 | 8·45 | 33·88 | 3·00 | 76·00 | 10,240 | 3·04 | 14·08 | 1·80 | 0·68 | |
| 27·4 | 22·0 | 8·35 | 34·06 | 2·83 | 74·00 | 10,600 | 2·14 | 2·80 | 2·00 | 0·80 | |
| 27·6 | 22·0 | 8·35 | 34·04 | 2·04 | 75·25 | 10,400 | 1·25 | 4·93 | 2·10 | 1·00 | |
| 27·4 | 22·0 | 8·35 | 34·16 | 3·17 | 75·25 | 10,400 | 2·14 | 2·80 | 1·85 | 1·50 | |
| 28·0 | 22·0 | 8·40 | 34·16 | 3·59 | 75·25 | 10,400 | 2·14 | 2·20 | 1·90 | 3·90 | |

TABLE 4—*The physico-chemical conditions of Pearl*

| *Station number.* | *Surface or bottom.* | *Colour.* | *Depth (metres).* | *Nature of bottom.* | *Visibility. (meters).* | *Current.* | *Sea or swell.* |
|---|---|---|---|---|---|---|---|
| *4th March* 1959 *Vellungu Karuval Par—* | | | | | | | |
| Central | Surface | Blue | 15·5 | Flat rocky | 11·5 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| S1 | Surface | Blue | 15·5 | Flat rocky | 12·0 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| S2 | Surface | Blue | 16·0 | Flat rocky | 12·0 | N—S | Ripples |
| | Bottom | .. | | | | .. | .. |
| S3 | Surface | Blue | 16·0 | Flat rocky | 12·0 | N—S | Ripples |
| | Bottom | | | | | | |
| *6th March* 1959 *Vellungu Karuval Par—* | | | | | | | |
| N2 | Surface | Blue | 17·0 | Flat rocky | 12·0 | N—S | Ripples |
| | Bottom | .. | | .. | .. | | .. |
| N4 | Surface | Blue | 18·0 | Flat rocky | 12·0 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *9th March* 1959 *Karuval Par—* | | | | | | | |
| N8—W1 | Surface | Blue | 16·0 | Rocky with sand | 12·0 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| N8—W3 | Surface | Blue | 15·5 | Rocky with sand | 12·5 | N—S | Ripples |
| | Bottom | | | | | | .. |
| N8—W4 | Surface | Blue | 16·5 | Rocky with sand | 12·5 | N—S | Ripples |
| | Bottom | .. | .. | .. | .. | .. | |
| *11th March* 1959 *Karuval Par—* | | | | | | | |
| N4—W2 | Surface | Blue | 16·5 | Rocky | 14·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| N8-W1-N1 | Surface | Blue | 17·0 | Sand over rock | 14·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| N8-W1-N2 | Surface | Blue | 16·5 | Sandy | 14·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *23rd March* 1959 *Thollayiram Par—* | | | | | | | |
| N—NE10 | Surface | Blue | 20·0 | Rocky with sand | 14·5 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| N-NE8 | Surface | Blue | 20·0 | Rocky with sand | 14·5 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| N-NE6 | Surface | Blne | 20·0 | Rocky with sand | 14·5 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *24th March* 1959 *Thollayiram Par—* | | | | | | | |
| N—NE4 | Surface | Bule | 21·0 | Flat rocky | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| N—NE2 | Surface | Blue | 21·0 | Flat rocky with sand. | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| W2 | Surface | Blue | 19·0 | Flat rocky with sand. | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| W4 | Surface | Blue | 21·0 | Flat rocky with sand. | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| E1 | Surface | Blue | 21·0 | Flat rocky with sand. | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| E3 | Surface | Blue | 21·0 | Flat rocky with sand. | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| E5 | Surface | Blue | 23·0 | Flat rocky with sand. | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| Central | Surface | Blue | 21·0 | Flat rocks | 15·0 | S—N | Ripples |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *26th March* 1959 *Thollayiram Par—* | | | | | | | |
| B1 | Surface | Blue | 19·5 | Rocky | 16·0 | N—S<br>(Weak) | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| B3 | Surface | Blue | 20·0 | Rocky | 16·0 | N—S | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| B5 | Surface | Blue | 22·0 | Sandy | 16·0 | N—S | Do. |
| | Bottom | . | .. | .. | .. | .. | .. |

*banks off Tuticorin during March* 1959—cont.

| *Temp.* °*C.* | *Sp. gr.* | *pH.* | *S°/oo.* | *Dissolved* $O_2$ *ml/L.* | *Excess base mg./L.* | *Calcium M. gm./L.* | *Silicate M. gm./L.* | $PO_4$—*P M. gm./L.* | $NO_3$—*N M. gm./L.* | *Iron M. gm./L.* | *Remarks.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27·2 | 22·2 | 8·35 | 34·30 | 5·10 | 70·28 | 10,800 | 1·25 | 0·70 | 1·00 | 2·50 | |
| 28·4 | 22·0 | 8·40 | 34·35 | 5·31 | 70·28 | 10,800 | 1·58 | 1·00 | 1·35 | 4·50 | |
| 27·5 | 22·2 | 8·30 | 34·28 | 4·83 | 71·15 | 10,700 | 0·89 | 0·80 | 1·00 | 1·00 | |
| 28·5 | 22·0 | 8·35 | 34·32 | 5·04 | 70·28 | 10,800 | 1·50 | 0·95 | 0·75 | 1·50 | |
| 27·8 | 22·1 | 8·35 | 34·30 | 5·35 | 70·28 | 10,800 | 1·00 | 0·75 | 0·75 | 0·80 | |
| 28·4 | 22·0 | 8·40 | 34·33 | 5·45 | 67·49 | 10,800 | 1·28 | 0·90 | 1·00 | 1·20 | |
| 27·9 | 22·1 | 8·35 | 34·30 | 4·95 | 69·95 | 10,700 | 0·85 | 0·80 | 0·90 | .. | |
| 28·4 | 22·0 | 8·35 | 34·35 | 5·05 | 67·49 | 10,700 | 1·28 | 1·00 | 1·25 | 1·20 | |
| | | | | | | | | | | | |
| 29·5 | 22·5 | 8·30 | 34·30 | 5·10 | 70·05 | 10,800 | 1·30 | 0·15 | 0·25 | 0·40 | |
| 28·6 | 22·0 | 8·30 | 34·35 | 5·04 | 70·05 | 11,000 | 1·30 | 0·30 | 0·50 | 2·40 | |
| 28·4 | 22·0 | 8·30 | 34·30 | 4·58 | 71·15 | 10,800 | 1·35 | 0·10 | 0·15 | .. | |
| 28·2 | 22·0 | 8·30 | 34·35 | 4·51 | 70·05 | 11,000 | 1·40 | 0·20 | 0·25 | 0·35 | |
| | | | | | | | | | | | |
| 28·0 | 22·0 | 8·30 | 34·32 | 5·04 | 67·75 | 11,000 | 2·00 | 1·50 | 2·00 | 0·45 | |
| 29·0 | 21·8 | 8·30 | 34·35 | 4·97 | 67·76 | 10,900 | 1·85 | 1·25 | 1·80 | 0·60 | |
| 28·0 | 22·1 | 8·35 | 34·30 | 4·00 | 68·25 | 10,800 | 1·00 | 0·85 | 1·00 | 1·50 | |
| 28·8 | 21·9 | 8·40 | 34·35 | 5·35 | 72·18 | 11,000 | 1·18 | 1·20 | 1·20 | 2·50 | |
| 28·2 | 22·1 | 8·35 | 34·32 | 5·04 | 70·18 | 10,800 | 0·85 | 0·55 | 0·80 | 0·80 | |
| 28·8 | 22·0 | 8·35 | 34·35 | 4·97 | 70·18 | 10,800 | 1·58 | 0·65 | 0·90 | 1·00 | |
| | | | | | | | | | | | |
| 28·0 | 22·0 | 8·25 | 34·35 | 3·52 | 70·84 | 11,000 | 1·10 | 0·80 | 1·00 | 1·35 | |
| 28·5 | 21·9 | 8·30 | 34·42 | 4·00 | 72·28 | 11,120 | 1·80 | 1·20 | 1·50 | 1·85 | |
| 27·9 | 22·2 | 8·30 | 34·35 | 3·80 | 74·00 | 11,200 | 0·85 | 1·00 | 1·25 | 0·94 | |
| 28·8 | 21·8 | 8·30 | 34·40 | 3·75 | 72·28 | 11,200 | 1·28 | 0·70 | 1·00 | 0·95 | |
| 27·9 | 22·2 | 8·25 | 34·36 | 3·32 | 74·06 | 11,120 | 0·85 | 0·70 | 1·00 | .. | |
| 28·6 | 22·0 | 8·30 | 34·43 | 3·75 | 72·28 | 11,200 | 0·28 | 0·70 | 0·80 | 0·20 | |
| | | | | | | | | | | | |
| 27·7 | 22·2 | 8·35 | 34·58 | 4·07 | 72·28 | 11,200 | 1·95 | 0·85 | 1·00 | 3·20 | |
| 28·7 | 22·0 | 8·35 | 34·51 | 3·93 | 72·28 | 11,200 | 1·85 | 1·00 | 1·25 | 4·80 | |
| 28·3 | 22·1 | 8·34 | 34·56 | 4·14 | 73·15 | 11,200 | 2·12 | 1·00 | 1·00 | 3·50 | |
| 38·7 | 22·0 | 8·35 | 34·61 | 4·15 | 72·28 | 11,240 | 1·85 | 1·50 | 1·70 | 3·00 | |
| 28·4 | 22·1 | 8·35 | 34·58 | 4·10 | 72·28 | 11,200 | 2·28 | 0·85 | 1·00 | 2·50 | |
| 28·6 | 22·1 | 8·35 | 34·61 | 4·15 | 72·28 | 11,240 | 2·50 | 1·00 | 1·40 | 4·50 | |
| | | | | | | | | | | | |
| 28·2 | 22·2 | 8·40 | 34·64 | 4·08 | 75·00 | 11,240 | 1·60 | 0·55 | 0·78 | 4·60 | |
| 29·2 | 22·0 | 8·40 | 34·64 | 4·14 | 72·00 | 11,350 | 1·60 | 0·45 | 0·79 | 2·80 | |
| 28·5 | 22·2 | 8·35 | 34·60 | 4·00 | 74·84 | 11,200 | 1·85 | 0·78 | 1·00 | 1·00 | |
| 28·9 | 22·1 | 8·40 | 34·48 | 4·28 | 72·02 | 11,200 | 1·60 | 0·75 | 1·00 | .. | |
| 28·4 | 22·1 | 8·40 | 34·50 | 4·17 | 74·06 | 11,200 | 1·98 | 0·50 | 0·42 | .. | |
| 28·9 | 22·1 | 8·40 | 34·59 | 3·93 | 70·28 | 11,240 | 1·70 | 0·30 | 0·25 | 1·00 | |
| 28·4 | 22·2 | 8·40 | 34·62 | 4·10 | 73·45 | 11,350 | 2·15 | 0·30 | 0·35 | 1·20 | |
| 28·8 | 22·1 | 8·45 | 34·52 | 4·13 | 70·28 | 11,350 | 1·90 | 0·15 | 0·25 | .. | |
| 28·3 | 22·2 | 8·40 | 34·57 | 4·17 | 72·25 | 11,300 | 2·28 | 0·95 | 1·25 | 2·50 | |
| 28·9 | 22·1 | 8·45 | 34·52 | 4·07 | 70·20 | 11,240 | 1·90 | 1·00 | 1·25 | 3·00 | |
| 28·7 | 22·1 | 8·40 | 34·52 | 4·07 | 73·65 | 11,240 | 2·00 | 0·85 | 1·00 | 2·80 | |
| 28·9 | 22·1 | 8·43 | 34·55 | 4·07 | 70·25 | 11,300 | 2·00 | 1·20 | 1·50 | 3·20 | |
| 29·2 | 22·0 | 8·40 | 34·54 | 4·10 | 74·84 | 11,350 | 2·12 | 1·05 | 1·80 | 2·70 | |
| 28·9 | 22·1 | 8·45 | 34·58 | 4·15 | 70·28 | 11,350 | 3·10 | 1·55 | 2·25 | 3·50 | |
| 29·4 | 22·0 | 8·35 | 34·52 | 4·00 | 74·06 | 11,240 | 2·15 | 1·80 | 2·50 | 3·80 | |
| 28·9 | 22·1 | 8·40 | 34·58 | 4·07 | 70·28 | 11,350 | 3·15 | 2·80 | 3·50 | 10·20 | |
| | | | | | | | | | | | |
| 29·4 | 22·0 | 8·30 | 34·78 | 4·00 | 72·18 | 11,400 | 1·60 | 0·80 | 1·00 | 1·00 | |
| 29·1 | 22·1 | 8·35 | 34·83 | 4·07 | 72·18 | 11,560 | 1·75 | 0·80 | 0·80 | 0·80 | |
| 28·8 | 22·1 | 8·35 | 34·83 | 4·07 | 70·28 | 11,560 | 2·00 | 1·00 | 1·00 | 0·35 | |
| 29·0 | 22·1 | 8·35 | 34·88 | 4·22 | 71·03 | 11,560 | 1·95 | 1·00 | 1·20 | 1·00 | |
| 28·4 | 22·2 | 8·40 | 34·74 | 4·08 | 72·18 | 11,400 | 3·00 | 0·80 | 1·00 | 2·00 | |
| 28·9 | 22·1 | 8·40 | 34·86 | 3·94 | 72·18 | 11,560 | 3·00 | 0·75 | 0·80 | 0·60 | |

TABLE 4—*Showing physico chemical conditions of pearl*

| *Station number.* | *Surface or bottom.* | *Colour.* | *Depth (metres).* | *Nature of bottom.* | *Visibility (metres).* | *Current.* | *Sea or swell.* |
|---|---|---|---|---|---|---|---|
| *30th March* 1959: *Thollayiram Par—* | | | | | | | |
| C11 | Surface | Blue | 25·0 | Sandy | 18·0 | S—N | Sea waves |
| | Bottom | .. | .. | .. | .. | .. | .. |
| C9 | Surface | Do. | 24·0 | Do. | 18·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| C7 | Surface | Do. | 20·0 | Sandy with broken shells, | 18·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| C6 | Surface | Do. | 20·0 | Rocky with sand | 18·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| C4 | Surface | Do. | 19·0 | Sandy | 17·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| C2 | Surface | Do. | 20·0 | Do. | 17·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |

TABLE 5—*Showing physico-chemical canditions of*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *2nd April* 1959 : *Thollayiram Par—* | | | | | | | |
| D-1 | Surface | Greenish | 18·0 | Sandy | 12·0 | S-N | Sea waves |
| | Bottom | .. | .. | .. | .. | .. | .. |
| D-3 | Surface | Blue | 18·0 | Rocky with sandy covering. | 12·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| D-6 | Surface | Do. | 19·5 | Do. | 12·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| D-7 | Surface | Do. | 19·5 | Rocky | 12·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| E-1 | Surface | Do. | 18·0 | Rocky with sand | 12·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| E-3 | Surface | Do. | 18·5 | Rocky | 12·5 | S—N | .. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *4th April* 1959 : *Thollayiram Par—* | | | | | | | |
| E-01 | Surface | Blue | 18·0 | Sand (15 cm.) over rock. | 11·0 | SE—NW | Sea waves |
| | Bottom | .. | .. | .. | .. | .. | .. |
| F-1 | Surface | Do. | 19·0 | Sandy with stray dead corals. | 11·0 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| F-3 | Surface | Do. | 17·5 | Do. | 11·0 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| F-5 | Surface | Do. | 19·4 | Rocky with 2 cm. of sand. | 11·0 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| F-7 | Surface | Do. | 22·0 | Sandy 25 cm. over rock | 11·0 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| G-1 | Surface | Do. | 17·0 | Do. | 10·0 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| G-3 | Surface | Do. | 18·0 | Sandy 5 cm· over rock. | 10·0 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| G-5 | Surface | Do. | 18·0 | Sandy 2 cm. over rock. | 10·5 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| G-7 | Surface | Do. | 19·5 | Do. | 10·5 | SE—NW | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| *7th April* 1959 : *Thollayiram Par—* | | | | | | | |
| H-1 | Surface | Greenish | 17·0 | Rock with sand | 10·5 | S—N | Sea waves |
| | Bottom | .. | .. | .. | .. | .. | .. |
| H-3 | Surface | Do. | 18·0 | Do. | 10·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| H-5 | Surface | Do. | 19·5 | Do. | 10·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| H-7 | Surface | Blue | 22·5 | Sandy over rock | 11·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| I-1 | Surface | Do. | 17·0 | Rocky | 10·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| I-3 | Surface | Do. | 17·0 | Sand over rock | 10·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| I-5 | Surface | Do. | 18·0 | Do. | 11·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |

*banks off Tuticorin during March* 1959—cont.

| *Temp.* °*C.* | *Sp. gr.* | *pH.* | *S°/oo.* | *Dissolved* $O_2$ *ml/L.* | *Excess base mg/L.* | *Calcium M. gm./L* | *Silicate M. gm./L.* | $PO_4$—*P M.gm,/L.* | $NO_3$—*N M. gm./L.* | *Iron M.gm./L* | *Remark.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28·5 | 22·1 | 8·35 | 34·64 | 2·14 | 72·25 | 11,400 | 2·30 | 1·00 | 1·25 | 2·20 | |
| 29·5 | 21·9 | 8·40 | 34·60 | 2·71 | 71·03 | 11,400 | 2·10 | 1·20 | 1·50 | 2·80 | |
| 28·7 | 22·0 | 8·35 | 34·67 | 2·77 | 73·35 | 11,300 | 2·20 | 1·05 | 1·50 | 2·10 | |
| 29·5 | 21·9 | 8·35 | 34·60 | 2·71 | 72·18 | 11,500 | 2·00 | 1·75 | 2·50 | 4·00 | |
| 28·8 | 22·1 | 8·40 | 34·85 | 2·58 | 74·08 | 11,560 | 1·95 | 0·95 | 1·00 | 2·10 | |
| | | | | | | | | | | | |
| 29·5 | 22·0 | 8·45 | 34·74 | 2·71 | 73·15 | 11,560 | 1·75 | 0·95 | 1·00 | 1·50 | |
| 28·9 | 22·0 | 8·40 | 34·62 | 2·59 | 72·28 | 11,500 | 1·95 | 0·75 | 1·00 | 0·80 | |
| 29·6 | 21·8 | 8·40 | 34·57 | 2·46 | 70·25 | 11,400 | 1·80 | 0·50 | 0·80 | 0·30 | |
| 28·9 | 22·0 | 8·40 | 34·69 | 2·46 | 74·06 | 11,500 | 2·15 | 0·95 | 1·40 | 0·85 | |
| 29·6 | 22·8 | 8·35 | 34·64 | 2·95 | 72·28 | 11,500 | 1·90 | 0·60 | 1·80 | 0·95 | |
| 29·0 | 22·0 | 8·35 | 34·62 | 0·69 | 74·84 | 11,500 | 2·15 | 0·50 | 0·60 | 0·70 | |
| 29·6 | 21·9 | 8·40 | 34·64 | 3·47 | 73·31 | 11,500 | 2·00 | 0·20 | . . | 0·75 | |

*pearl banks off Tuticorin during April* 1959.

| *Temp.* °*C.* | *Sp. gr.* | *pH.* | *S°/oo.* | *Dissolved* $O_2$ *ml/L.* | *Excess base mg/L.* | *Calcium M. gm./L* | *Silicate M. gm./L.* | $PO_4$—*P M.gm,/L.* | $NO_3$—*N M. gm./L.* | *Iron M.gm./L* | *Remark.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28·6 | 22·0 | 8·45 | 34·25 | 3·56 | 72·21 | 11,000 | 2·32 | 0·18 | 0·70 | 1·00 | |
| 29·5 | 21·7 | 8·50 | 34·22 | 4·02 | 71·22 | 10,800 | 2·18 | 0·22 | 0·40 | 4·70 | |
| 28·5 | 22·0 | 8·45 | 34·31 | 3·47 | 70·89 | 11,000 | 3·04 | 0·14 | . . | 0·30 | |
| | | | | | | | | | | | |
| 29·6 | 21·7 | 8·50 | 34·28 | 4·02 | 72·21 | 10,600 | 2·18 | 0·22 | 0·43 | 0·40 | |
| 28·8 | 21·9 | 8·45 | 34·28 | 3·70 | 70·89 | 10,680 | 1·88 | 0·18 | 0·40 | 0·70 | |
| 29·7 | 21·7 | 8·47 | 34·30 | 4·11 | 70·89 | 10,800 | 2·50 | 0·22 | . . | 0·60 | |
| 29·0 | 21·8 | 8·45 | 34·28 | 3·64 | 72·21 | 10,880 | 2·00 | 0·14 | . . | 0·30 | |
| 29·6 | 21·6 | 8·50 | 34·28 | 4·08 | 72·21 | 10,800 | 1·80 | 0·22 | 0·12 | 0·40 | |
| 29·4 | 21·9 | 8·45 | 34·30 | 3·15 | 71·22 | 10,800 | 2·00 | 0·16 | . . | 0·40 | |
| 29·6 | 21·6 | 8·50 | 34·28 | 4·11 | 17·89 | 10,880 | 1·80 | 0·25 | 0·21 | 1·35 | |
| 29·4 | 21·9 | 8·45 | 34·32 | 3·88 | 72·21 | 11,000 | 2·18 | 0·15 | 0·09 | 1·20 | |
| 29·8 | 21·6 | 8·50 | 35·30 | 4·00 | 72·21 | 10,920 | 2·00 | 0·22 | 0·25 | 0·40 | |
| | | | | | | | | | | | |
| 29·0 | 21·8 | 8·45 | 34·33 | 2·43 | 68·37 | 11,000 | 1·50 | 0·15 | . . | 0·50 | |
| | | | | | | | | | | | |
| 29·9 | 21·6 | 8·55 | 34·28 | 3·84 | 72·21 | 10,920 | 1·60 | 0·20 | 0·22 | 0·45 | |
| 29·1 | 21·8 | 8·45 | 34·32 | 3·56 | 69·62 | 10,800 | 1·60 | 0·10 | . . | . . | |
| | | | | | | | | | | | |
| 29·9 | 21·6 | 8·50 | 34·38 | 3·86 | 71·03 | 10,880 | 1·60 | 0·20 | 0·09 | . . | |
| 29·2 | 21·8 | 8·45 | 34·35 | 3·52 | 69·52 | 11,000 | 1·70 | 0·15 | 0·10 | 0·30 | |
| 29·9 | 21·6 | 8·50 | 34·30 | 3·56 | 69·52 | 10,550 | 1·70 | 0·20 | 0·15 | 0·45 | |
| 29·2 | 21·8 | 8·50 | 34·45 | 3·37 | 69·52 | 11,000 | 1·60 | 0·10 | . . | . . | |
| | | | | | | | | | | | |
| 29·8 | 21·6 | 8·55 | 34·31 | 3·96 | 72·21 | 10,800 | 1·60 | 0·22 | 0·15 | . . | |
| 29·1 | 21·8 | 8·50 | 34·35 | 3·71 | 70·28 | 10,450 | 2·00 | 0·12 | . . | . . | |
| 29·8 | 21·6 | 8·50 | 34·30 | 3·89 | 70·28 | 10,400 | 2·00 | 0·25 | 0·25 | 0·50 | |
| 29·4 | 21·9 | 8·50 | 34·32 | 3·46 | 79·52 | 10,600 | 2·00 | 0·10 | . . | 0·30 | |
| 30·0 | 21·5 | 8·50 | 34·40 | 3·75 | 68·37 | 10,400 | 2·00 | 0·18 | . . | . . | |
| 29·4 | 21·7 | 8·50 | 34·35 | 3·77 | 69·52 | 10,400 | 1·80 | 0·09 | 0·30 | 0·70 | |
| 29·9 | 21·6 | 8·50 | 34·31 | 3·78 | 70·28 | 10,400 | 1·80 | 0·18 | 0·20 | 1·09 | |
| 29·6 | 21·6 | 8·50 | 34·28 | 3·77 | 70·28 | 10,320 | 2·00 | 0·10 | . . | 0·65 | |
| 29·9 | 21·6 | 8·55 | 34·30 | 3·94 | 70·28 | 10,400 | 3·00 | 0·25 | 0·30 | 0·40 | |
| 29·3 | 21·8 | 8·00 | 34·30 | 3·78 | 69·52 | 10,400 | 2·70 | 0·08 | . . | . . | |
| 30·1 | 21·4 | 8·55 | 34·10 | 3·92 | 68·37 | 10,600 | 3·60 | 0·20 | 0·20 | 0·70 | |
| | | | | | | | | | | | |
| 29·3 | 21·9 | 8·45 | 34·40 | 3·37 | 70·28 | 10,800 | 1·25 | 0·10 | . . | 0·50 | |
| 30·0 | 21·5 | 8·45 | 34·38 | 3·88 | 69·52 | 11,000 | 1·25 | 0·15 | 0·07 | 0·80 | |
| 29·4 | 21·8 | 8·45 | 34·38 | 3·50 | 70·28 | 10,550 | 1·36 | 0·20 | 0·30 | 0.70 | |
| 30·1 | 21·5 | 8·40 | 34·38 | 4·03 | 70·23 | 10,800 | 1·36 | 0·45 | 0·75 | 0·54 | |
| 29·6 | 21·8 | 8·40 | 34·36 | 3·31 | 69·52 | 10,000 | 1·25 | 0·50 | 0·64 | 1·35 | |
| 30·1 | 21·6 | 8·50 | 34·38 | 3·99 | 71·43 | 10,400 | 1·25 | 0·08 | 0·10 | 0·54 | |
| 29·5 | 21·8 | 8·45 | 34·40 | 3·62 | 79·28 | 10,250 | 1·25 | 0·25 | 0·43 | 0·54 | |
| 30·0 | 21·6 | 8·50 | 34·40 | 4·25 | 71·03 | 10,400 | 1·14 | 0·25 | 0·60 | 0·70 | |
| 29·6 | 21·8 | 8·45 | 34·42 | 3·45 | 79·52 | 10,400 | 1·36 | 0·36 | 0·80 | 0·54 | |
| 30·0 | 21·6 | 8·40 | 34·35 | 4·05 | 90·28 | 10,400 | 1·25 | 0·14 | . . | 0·40 | |
| 29·7 | 21·8 | 8·45 | 34·42 | 4·15 | 71·03 | 10,300 | 1·25 | 0·30 | 0·45 | 1·08 | |
| 30·0 | 21·6 | 8·40 | 34·38 | 4·05 | 71·03 | 10,320 | 1·14 | 0·35 | 0·80 | 0·40 | |
| 29·8 | 21·8 | 8·50 | 34·42 | 3·78 | 70·28 | 10,400 | 1·36 | 0·25 | 0·50 | 0·90 | |
| 30·1 | 21·6 | 8·45 | 34·40 | 3·94 | 69·52 | 10,400 | 1·25 | 0·25 | 0·60 | 0·40 | |

### TABLE 5—*Showtng physico chemical conditions of pearl*

| *Station number.* | *Surface or bottom.* | *Colour.* | *Depth (metres).* | *Nature of bottom.* | *Visilbilty (metres).* | *Current.* | *Sea or swell.* |
|---|---|---|---|---|---|---|---|
| 13*th April* 1959 : *Thollayiram Par*— | | | | | | | |
| I-0 | Surface | Blue | 15·0 | Rock with sand | 10·5 | S—N | Sea waves |
| | Bottom | .. | .. | .. | .. | .. | .. |
| I-01 | Surface | Do. | 15·0 | Do. | 10·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| J-1 | Surface | Do. | 15·0 | Do. | 10·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| J-3 | Surface | Do. | 16·5 | Do. | 10·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| J-5 | Surface | Do. | 17·5 | Do. | 11·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| J-7 | Surface | Do. | 19·0 | Do. | 10·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| 17*th April* 1959 : *Thollayiram Par*— | | | | | | | |
| K-1 | Surface | Blue | 17·0 | Sandy | 11·0 | S—N | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| K-3 | Surface | Do. | 17·0 | Rock with sand (6cm). | 10·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| K-5 | Surface | Do. | 16·0 | Rock with 5 cm. of sand. | 10·5 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| K-7 | Surface | Do. | 18·0 | 20 cm. of sand over rock. | 11·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| K-9 | Surface | Do. | 20·0 | Sandy | 11·0 | S—N | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| 18*th April* 1959 : *Thollayiram Par*— | | | | | | | |
| L-1 | Surface | Blue | 16·0 | Sandy | 10·0 | N—S | Swell |
| | Bottom | .. | .. | .. | .. | .. | .. |
| L-4 | Surface | Do. | 16·0 | Rock with sand | 10·0 | N—S | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| L-7 | Surface | Do. | 18·0 | Do. | 10·0 | N—S | Do. |
| | Bottom. | .. | .. | .. | .. | .. | .. |
| M-1 | Surface | Do. | 14·0 | Sandy with broken shells. | 10·0 | N—S | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| M-4 | Surface | Do. | 17·0 | Rock with sand | 10·0 | N—S | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| M-7 | Surface | Do. | 20·5 | Do. | 9·5 | N—S | Do. |
| | Bottom. | .. | .. | .. | .. | .. | .. |

### TABLE 6—*The physico-chemical conditions of pearl*

| *Station number.* | *Surface or bottom.* | *Colour.* | *Depth (metres).* | *Nature of bottom.* | *Visibility. (metres).* | *Current.* | *Sea or swell.* |
|---|---|---|---|---|---|---|---|
| 6*th May* 1959 : *Off Mannapad* (13 miles west of Mannapad point) (8°—22′ 50′ N and 78°—19″ E.)— | | | | | | | |
| 1 South-West. | Surface | Blue | 19·5 | Rocky with sand | 12·0 | S—N | Sea high waves. |
| | Bottom | .. | .. | .. | .. | .. | .. |
| 2 North-East | Surface | Do. | 20·0 | Rocky with sand rich in sponges and live corals. | 12·0 | SW—NE | Do. |
| | Bottom | .. | .. | .. | .. | .. | .. |

banks off *Tuticorin during April* 1959—cont.

| *Temp. °C,* | *Sp. gr.* | *pH.* | *S°/00.* | *Dissolved $O_2$ ml/L.* | *Excess base ml/L.* | *Calcium U. gm./L.* | *Silicate U. gm./L.* | *$PO_4$—P U.gm./L.* | *$NO_3$—N U. gm./L.* | *Iron U. gm. /L.* | *Remarks.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29·6 | 21·8 | 8·40 | 34·48 | 2·46 | 71·43 | 10,400 | 1·25 | 0·25 | .. | 0·25 | |
| 29·9 | 21·7 | 8·45 | 34·48 | 3·47 | 70·28 | 10,000 | 1·14 | 0·35 | 0·80 | 0·40 | |
| 30·0 | 21·6 | 8·40 | 34·49 | 3·48 | 69·52 | 10,400 | 1·25 | 0·15 | .. | 0·30 | |
| 30·1 | 22·5 | 8·45 | 34·35 | 3·77 | 69·62 | 10,400 | 1·14 | 0·14 | .. | 0·40 | |
| 30·0 | 21·6 | 8·35 | 34·49 | 3·30 | 70·28 | 10,320 | 1·25 | 0·35 | 0·85 | 0·40 | |
| 30·2 | 21·6 | 8·40 | 34·55 | 3·82 | 71·03 | 10,400 | 1·25 | 0·20 | 0·35 | 0·40 | |
| 29·9 | 21·6 | 8·35 | 34·48 | 3·77 | 70·28 | 10,320 | 1·25 | 0·24 | .. | 0·40 | |
| 30·1 | 21·5 | 8·35 | 34·12 | 3·82 | 72·02 | 10,000 | 1·25 | 0·30 | 0·85 | 0·45 | |
| 29·8 | 21·6 | 8·40 | 34·40 | 3·77 | 70·28 | 10,320 | 1·14 | 0·14 | 0·30 | .. | |
| 30·0 | 21·5 | 8·40 | 34·23 | 3·91 | 69·52 | 10,400 | 1·07 | 0·25 | 1·00 | 0·35 | |
| 29·5 | 21·8 | 8·40 | 34·27 | 3·78 | 69·52 | 10,320 | 0·90 | 0·10 | 0·77 | 0·30 | |
| 29·9 | 21·5 | 8·45 | 34·28 | 3·95 | 69·52 | 10,400 | 1·62 | 0·18 | 0·10 | 0·35 | |
| | | | | | | | | | | | |
| 30·7 | 21·6 | 8·40 | 34·55 | 3·89 | 70·28 | 10,400 | 1,00 | 0·18 | .. | 0·30 | |
| 30·4 | 21·7 | 8·45 | 34·52 | 3·92 | 70·28 | 10,400 | 1·07 | 0·09 | .. | .. | |
| 30·8 | 21·6 | 8·45 | 34·57 | 3·99 | 70·28 | 10,320 | 1·00 | 0·15 | .. | .. | |
| 30·6 | 21·7 | 8·45 | 34·57 | 3·83 | 69·52 | 10,400 | 1·07 | 0·10 | .. | 0·35 | |
| 30·8 | 21·6 | 8·45 | 34·52 | 3·95 | 70·28 | 10,200 | 1·00 | 0·18 | 0·20 | 0·40 | |
| | | | | | | | | | | | |
| 30·4 | 21·7 | 8·50 | 34·52 | 3·97 | 69·52 | 10,320 | 1·07 | 0·18 | 0·10 | 0·40 | |
| 31·1 | 21·4 | 8·45 | 34·55 | 3·95 | 70·28 | 10,400 | 1·00 | 0·15 | .. | 0·25 | |
| | | | | | | | | | | | |
| 30·6 | 21·5 | 8·40 | 34·49 | 3·85 | 70·28 | 10,400 | 1·00 | 0·25 | 0·15 | 0·25 | |
| 31·1 | 21·4 | 8·40 | 34·40 | 4·03 | 70·28 | 10,200 | 1·00 | 0·18 | .. | 0·40 | |
| 30·6 | 21·5 | 8·45 | 34·49 | 3·95 | 70’28 | 10,200 | 1·00 | 0·22 | 0·15 | .. | |
| | | | | | | | | | | | |
| 30·7 | 21·6 | 8·50 | 34·57 | 4·03 | 70·28 | 11,120 | 0·80 | 1·85 | 0·50 | 0·40 | |
| 30·6 | 21·6 | 8·40 | 34·48 | 4·16 | 70·28 | 11,200 | 0·70 | 0·45 | 0·60 | 1·40 | |
| 30·8 | 21·6 | 8·45 | 34·60 | 4·22 | 72·18 | 10,800 | 0·80 | 0·10 | 0·47 | 0·40 | |
| 30·6 | 21·7 | 8·40 | 34·57 | 3·96 | 72·18 | 11,200 | 0·70 | 0·50 | 0·57 | 1·50 | |
| 30·9 | 21·5 | 8·40 | 34·57 | 4·16 | 72·18 | 11,000 | 0·90 | 0·50 | 0·50 | 0·45 | |
| 30·6 | 21·6 | 8·40 | 34·55 | 4·13 | 69·52 | 11,400 | 0·70 | 0·50 | 0·60 | 1·00 | |
| 30·9 | 21·6 | 8·35 | 34·60 | 4·16 | 77·03 | 11,400 | 0·90 | 0·40 | 0·36 | 1·50 | |
| 30·7 | 21·6 | 8·35 | 34·57 | 4·05 | 70·28 | 10,800 | 0·70 | 0·40 | 0·48 | 1·60 | |
| | | | | | | | | | | | |
| 31·0 | 21·5 | 8·50 | 34·48 | 4·13 | 72·18 | 11,000 | 0·90 | 0·25 | 0·22 | 2·80 | |
| 30·6 | 21·6 | 8·50 | 34·52 | 4·21 | 70·28 | 11,000 | 0·80 | 0·80 | 0·70 | 1·60 | |
| 31·4 | 21·5 | 8·30 | 34·57 | 4·13 | 70·28 | 11,320 | 0·90 | 0·45 | 0·43 | 0·32 | |
| 30·7 | 21·6 | 8·40 | 34·48 | 3·97 | 70·28 | 10,800 | 0·70 | 1·00 | 0·95 | 0·80 | |

banks off *Tuticorin during May* 1959.

| *Temp. °C.* | *Sp. gr.* | *pH.* | *S°/00.* | *Dissolved $O_2$ m /L.* | *Excess base mg/L.* | *Calcium u. gm. at/L.* | *Silicate u. gm. at/L.* | *$PO_4$—P u. gm. at/L.* | *$NO_3$—N u.gm. at/L.* | *Iron u. gm. at/L.* | *Remarks.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 30·5 | 21·6 | 8·45 | 34·57 | 3·75 | 70·50 | 11,200 | 0·90 | 0·50 | 0·50 | 1·30 | |
| | | | | | | | | | | | |
| 30·2 | 21·8 | 8·50 | 34·52 | 4·20 | 69·00 | 11,000 | 0·90 | 0·20 | .. | .. | |
| 30·4 | 21·7 | 8·40 | 34·52 | 3·74 | 69·60 | 11,120 | 1·07 | 0·40 | 0·36 | 0·25 | |
| | | | | | | | | | | | |
| 30·2 | 21·8 | 8·55 | 34·50 | 3·92 | 69·00 | 11,000 | 1·07 | 0·40 | 0·42 | 0·80 | |

# A REVIEW OF THE PHYSICO-CHEMICAL ENVIRONMENTAL CONDITIONS OF THE PEARL BANKS AND CHANK-BEDS OFF TUTICORIN IN THE GULF OF MANNAR DURING APRIL 1960–MARCH 1961.

BY

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## Introduction.

The pearl-banks and chank-beds off Tuticorin in the Gulf of Mannar are productive of valuable shell fishes. The Thollayiram par and the other pearl banks adjacent to it have yielded since 1955 an annual harvest of about 10 million oysters of remarkable pearl-content. From the chank beds about 1·0-1·20 million chanks are fished. However, no systematic information on the environmental conditions existing in these beds are available except for a few observations by Chacko and Malu Pillai (1956 and 1957) and by Chidambaram, Rajendran and Valsan (1951). Malu Pillai (under publication) has made an attempt to present a comprehensive picture of the meteorological and physico-chemical conditions of the Pearl Banks off Tuticorin. The present paper is another attempt in this direction.

## Materials and Methods.

Samples of water from the pearl-banks and chank-beds were collected both from the surface and bottom normally three days in a week using Knudsen's reversible water-bottle. Zambra and Negretta Deep-Sea Reversible Thermometer (protected type) was used for temperature reading. The major meteorological elements were recorded daily, and for this the standard apparatus described by Roy (1953) were used and for the other hydro-graphical condition methods and equipments described by Harvey (1945, 1957) and Barnes (1959) were adopted. Lumeton Photoelectric colorimetre was used for colorimetre estimation of phosphate and silicate.

## Maritime Meteorology.

The monthly average of temperature of the air, humidity pressure, rainfall and wind-velocity are given in Table No. 1.

The region is exposed to both the monsoons. The South-west monsoon commences by the middle of April and prevails up to September and the North-east monsoon from the middle of October to February. March and September are the transition period. The South-west monsoon was in full vigour with speed up to 45 km. but brought only 20·9 cm. of rainfall out of the total of 110·33 cm. During the peak season when the West-Coast of India, had a good precipitation, this region was dry. The North-east monsoon, although of much less vigour, brought a total of 79·48 cm. of rainfall. In November about 45 cm. of rain was recorded.

## Temperature.

The atmosphere was hot with temperature between 22·0°C and 39·0°C during April to October, which was the summer period. During November-February, it was between 20·0 and 31·0°C which was the winter period. March was also hot, the atmospheric temperature exhibited 2 maxima, one in June and the other in August and similarly two minima in July and January.

## Humidity.

The atmosphere was dry especially during August-September. During the South-west monsoon period it was less humid, the monthly average being 56·78 per cent. However, during the North-east monsoon period, atmosphere was humid and humidity conditions above 80 per cent observed as recorded by Paton (1936) in South and South-East Arabian sea.

## Rain-Fall.

The total rain-fall during the year was 10·38. The monthly rainfall graph and humidity graph were found to be of the same pattern.

## Pressure.

Pressure was normal ranging between 76·625 cm. in June and 76·740 cm. in December. Generally the pressure during the South-west monsoon season was low and during the North-east monsoon season it was high. The monthly average pressure graph was more or less of the same pattern as that of humidity.

## Wind.

The wind velocity curve was a trimodal one with maxima in June, August-September and December and minima in April, July and November. The minimum in November and the maximum in January were remarkable. Velocity was comparatively much less during North-east monsoon than in the South-west monsoon.

## Hydrography.

The monthly average values of the depth of the place, nature of the bottom, colour of the water, visibility, current, condition of sea, temperature, specific gravity, salinity, dissolved oxygen, excess-base, calcium, silicate-silicon and phosphate-phosphorous given in Table 2.

## Temperature.

The water was warm with temperature ranging between 26·0°C in November and January and 30·5°C in May. The graph exhibited three prominent modes with peak in May, July and October. The fall in temperature during June, August and January was very sudden and deep. The water was warm from April to August and in October and March with a higher temperature invariably above 28°C. However, from November to February it was cool, and January recorded very cool waters with temperature between 26·0 and 27·3°C.

### Specific Gravity.

This ranged between 23·0 in February and 25·0 in October. Generally it was high during South-west monsoon period and low during the North-east monsoon.

### Hydrogen ion Concentration.

This factor was between 8·10 in May, August, November, December and 8·6 from in August to November. The average value graph exhibited a trimodal curve with peaks in May, October and March and minima in April, July and December, the decline in December being very pronounced.

### Colour.

The colour of the water varied between attractive blue to greenish-blue. During July and from November to January it was more greenish indicating probably the presence of phyto-plankton.

### Current.

From May to August the current was from south to north, i.e., the waters from the Arabian Sea flowing into Gulf and during April and September-March, the current was in the opposite direction, i.e., waters of the Palk Bay flowing into the Gulf. Occassional reversal of the current during August and February had also been recorded.

### Conditions of Sea.

Generally the sea was disturbed. Broad and high waves were noticed during the peak of the South-west monsoon. Comparatively calm conditions existed during the other period, with occassionally very calm conditions.

### Depth.

The depth of water over the pearl-banks was about 20 metres and chanks have been found even in deeper waters.

### Visibility.

Visibility varied between 6·0 metres in July and 19 metres in November. Visibility was good during April-June and November-December and in February.

### Nature of Bottom.

Pearl banks are of calcite rock with 25–57 mm. Overlayer of sand and shell grit were also noticed in certain places. The chank-bed are sandy and of coarse sand without any mud.

### Salinity.

This ranged between 32·07 per cent in November and 35·91 per cent in September and was high in South-west monsoon months of August-September and in October and very low during North-east monsoon months of November to February. Lowest values were observed during December.

### Dissolved Oxygen.

Varied from 6·84 cc./1 in October to 3·4 cc./1 in September. Oxygen super-saturated water was also recorded. The graph exhibited trimodal curve with distinct peaks in June-October and January and declines in April, September and November. During the North-east monsoon months, the oxygen saturation was more and during the South-west season it was less.

### Silicate.

Wide and sudden variations between 90 mg.m/1 in March and traces (in October and January)were recorded. During June-July, November-December and February-March it was high and during August-September, October and January it was less.

### Phosphate.

Sudden fluctuations between 8 m.gm./litre in June and nil during August to December and again in February, March were the features of variation in phosphate. Complete absence of phosphate was frequently met with during the above period. Generally phosphate was rather low. During the South-west monsoon period when the current was from south and north, phosphate was fairly rich. However, during the North-east monsoon period paucity of this nutrient was frequently met with.

### Alkalinity or Excess Base.

No remarkable variations could be observed during the period. The variation was between 67·5 mg./1 in November and 71·5 mg./1 from July to November. The alkalinity was high throughout except for the slight fall in May and December.

### Calcium.

The calcium content varied between 10,490 mgm/1 in November and 12,930 mgm. /1 in October. The average Calcium content graph indicated three modes with maxima in June, September and December and minima in April, August and November. There was a tendency to form yet another peak with maximum in March and minimum in January.

### General Conditions of Plankton.

Fish eggs and larvae were commonly seen during August-October. Zoo-organisms like *copepods*, *ceratium* and *Sagitta* were predominating during the period. Phyto-organisms in August and from October to February. Although phyo-planktonic organsims like *Coscinodiscus*, *Biddulphia Chaetoceros*, etc. were common,*Noctiluca* bloom was observed in October. Planktonic peak was observed in December also.

### Discussion.

The prevailing two monsoons seemed to have a very great effect on the major meteorological and hydrographical factors. The sudden drop in the temperature of the atmosphere during July was attributable to the high humidity and precipitation. The abnormal lowering in temperature during November to February was again attributable to the strong wind, high humidity and precipitation. The pressure was high during November and December when humidity of the air and precipitation were also high.

The surface temperature graph is of the same pattern as the atmosphere temperature graph during the South-west monsoon period, but the periods of maximum surface temperature preceded the corresponding maximum of the atmosphere. But during the peak North-east monsoon period, the graphs were more or less alike. During August-September reverse conditions were noticed. This was probably due to the sudden increase in the wind velocity and the reversal of the current system when cold water from the Palk Bay flowed into the Gulf.

The sudden decrease in salinity during June in spite of the South-north current may probably be due to the effect of heavy rain in the South and South-east Arabian Sea and in the catchment area of river Tambaraparni. The high salinity during August to October might be due to evaporation caused by the sudden increase in the wind velocity and due to the high atmospheric temperature. The remarkable lowering during the North-east monsoon is due to the inflow of fresh water.

The abnormal lowering of pH value during December might be due to the influx of fresh water. Supersaturation of oxygen was indicative of greater photo-synthesis due to the presence of thick phyto-plankton, nanno-plankton. Low oxygen in April-May and in September was suggestive of greater rate of respiration than photo-synthesis.

Greater utilisation of silicate during April-May, September-October and in December-January might probably be for the formation of silicious exo-skeletons of the diatoms. The abnormally high concentration of silicate during November and February-March might be due to the dissolution of excreta of the diatom grazing copepods and other organisms which were in peak and the dissolution and decomposition of the diatoms themselves.

Low phosphate content almost throughout the year was suggestive of a good standing crop, especially from July onwards. The high oxygen concentration inspite of zoo-organisms throughout the year indicated that the water was fertile but the nutrients like phosphate are absorbed by phyto and nanno-planktonic organisms. The increase in salinity following lowering and the slight fall in temperature give the impetus for the off-shoot of phyto-organisms. The rich pasture grounds provided, following the off-shoot of plankton would give the necessary impetus for fishes to breed. This as well as the oceanic salinity and slightly low temperature would even be responsible for a shore-ward migration of certain pelagic fishes. Greater utilisation of Calcium during April-May was suggestive of spat-fall during that period. High calcium in June-July and in September may be due to the dissolution of calcium carbonate forming the ooze and dead calcareous organisms or due to the influx of fresh water rich in calcium.

The absence of effective vertical gradient of temperature, salinity, or oxygen was suggestive of a good mixing up of the water.

It might be said that the water of the pearl-banks would be fairly warm, highly saline and rich in calcium. The water was rich in dissolved oxygen and it substained a good standing crop and nanno-plankton organisms which form the food of the pearl oysters.

## Summary.

(1) Meteorological and hydrographical conditions of the pearl-banks off Tuticorin are brought out and discussed.

(2) The profound effect of the current systems caused by the two monsoons are discussed.

(3) The shore-ward migration of certain pelagic fishes are indicated.

(4) Season of spat-fall of pearl oysters has been suggested.

(5) Good vertical mixing of waters is established.

## Acknowledgment.

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TABLE 1.—*Maritime Meteorology of the Tuticorin Bay during April 1960 to March 1961.*

| *Month.* | *Temperature °C.* | | | *Humidity.* | | | *Pressure (cm.).* | | | *Rain fall. (cms.)* | *Wind.* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | *Direction.* | *Speed KM/hr.* | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| | MAX. | MIN. | AVER. | MAX. | MIN. | AVER. | MAX. | MIN. | AVER. | | | MAX. | MIN. | AVER. |
| | | | | | | | | | | | Between | | | |
| April .. .. .. | 38·0 | 23·0 | 29·63 | 100 | 60 | 77·68 | 76·625 | 76·100 | 76·343 | 12·2 | SW-N and SE .. | 45 | .. | 8·0 |
| May .. .. .. | 38·0 | 24·0 | 30·30 | 90 | 45 | 68·25 | 76·325 | 76·100 | 76·176 | 4·4 | W, S. and ENE | 32 | 3 | 12·4 |
| June .. .. .. | 39·0 | 25·0 | 31·80 | 75·0 | 53·0 | 61·0 | 76·250 | 76·025 | 76·157 | .. | W, S, SW .. | 38·2 | 3 | 21·3 |
| July .. .. .. | 36·0 | 23·0 | 28·03 | 95 | 50 | 62·58 | 76·275 | 76·100 | 76·190 | 2·9 | W, S and N .. | 38·2 | 3·2 | 16·99 |
| August .. .. .. | 37·0 | 22·0 | 30·5 | 80 | 40 | 58 | 76·370 | 76·100 | 76·161 | .. | NW, WSW and ENE, | 42·2 | 3·2 | 19·4 |
| September .. .. | 37·0 | 24·0 | 30·10 | 90 | 50 | 59·8 | 76·325 | 76·075 | 76·191 | 1·4 | W, W, SW and N | 35·2 | 3·2 | 19·4 |
| October .. .. .. | 36·0 | 22·0 | 28·13 | 100 | 45 | 73·4 | 76·575 | 76·125 | 76·300 | 15·4 | WSW, NW and NE, | 22·4 | 6·4 | 12·7 |
| November .. .. | 31·0 | 22·0 | 26·0 | 100 | 70 | 86 | 76·575 | 76·345 | 76·478 | 45·1 | SW, N and SE .. | 16·9. | 3·2 | 8·4 |
| December .. .. | 30·0 | 20·0 | 25·5 | 95 | 70 | 81 | 76·740 | 76·330 | 76·530 | 2·98 | NNW, N and SSE | 29·2 | 3·2 | 16·95 |
| January 1961 .. .. | 30·0 | 20·0 | 24·9 | 95 | 70 | 85·5 | 76·685 | 76·435 | 76·596 | 15·6 | WNW, N and ENE | 22·13 | 10·5 | 15·4 |
| February .. .. .. | 30·0 | 21·0 | 25·94 | 90 | 60 | 79·82 | 76·675 | 76·350 | 76·493 | .. | NNW, N, NNE | 26·14 | 0·0 | 13·15 |
| March .. .. .. | 35·0 | 23·0 | 27·45 | 100 | 65 | 81 | 76·700 | 76·315 | 76·520 | 0·4 | SW, NNE and N. | 22·12 | 3·5 | 12·7 |

TABLE 2—*The Physical Factors of the Pearl Banks off Tuticorin during April 1960—March 1961.*

| *Month.* | *Locality.* | *Colour.* | *Current.* | *Sea or swell.* | *Depth (m.).* | | | *Visibility (m).* | | | *Nature of bottom.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6)<br>MAX. | (7)<br>MIN. | (8)<br>AVER. | (9) | (10) | (11) | (12) |
| April | Thollayiram par | Attractive or Greenish blue. | N–S | Waves | 19 | 18 | 18·8 | 16·5 | 15·0 | 15·7 | Par with sand and shell grit. |
| May | Do. | Light blue | SE–NW | Broad waves. | 19 | 18 | 18·5 | 15·0 | 13·0 | 13·5 | Do. |
| June | Thollayiram par and Koothadiar par. | Light blue to bluish green. | SE–NW | Broad waves. | 19 | 18 | 18·3 | 15 | 13 | 13·9 | Do. |
| July | Thollayiram par and Karaj par. | Greenish blue. | S–N | Waves (High). | 18 | 14 | 17·0 | 10 | 6 | 7·3 | Do. |
| August | Thollayiram par | Bluish or fine green. | SE–NW on 2 days N–S. | Broad waves. | 19 | 15 | 18·0 | 14·0 | 8·5 | 12·2 | Do. |
| September | Do. | Bluish | N–S | Swells and waves. | 20 | 18 | 18·5 | 13 | 12·0 | 12·7 | Do. |
| October | Thollayiram par Koothadiar par Pasi par, Patharai par. | Bluish or greenish | N–S | Waves and swells. | 19 | 17 | 18·0 | 13 | 10·5 | 12·5 | Do. |
| November | Thollayiram and Karaikalathi par. | Greenish and bluish. | N–S | Swell waves. | 19·0 | 17·0 | 17·5 | 19 | 12·0 | 13·0 | Do. |
| December | Thollayiram par. | Blue | N–S | Swells | 21·0 | 18·0 | 19 | 14 | 13 | 13·7 | Par with fine sand scattered oysters and fish. |
| January | Thollayiram par, Karai par, Kothadiar par. | Green and blue. | W–S | Waves | 19 | 14 | 17 | 10·5 | 8·0 | 9·5 | Par with sand and shell grit. |
| February | Thollayiram par. | Attractive blue. | S–N and N–S | Waves | 19·0 | 16·0 | 17·5 | 14·0 | 13·0 | 13·75 | Do. |
| March | Do. | Attractive blue or green. | N–S | Swells | 20·0 | 16·0 | 18 | 16 | 15 | 15·3 | Par with little sand and good population. |

TABLE 3—*The Physico Chemical Factors of the Pearl Banks off Tuticorin during April 1960—March 1961.*

| *Temperature °C,* | | | *Specific gravity,* | | | *pH,* | | | *Salinity (%),* | | | *Dissolved oxygen cc/L,* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX, | MIN, | AVER, | MAX, | MIN, | AVER, | MAX. | MIN, | AVER, | MAX, | MIN, | AVER, | MAX, | MIN, | AVER, |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| 30·3 | 29·5 | 29·98 | 24·3 | 24·1 | 24·2 | 8·4 | 8·1 | 8·30 | 34·50 | 34·15 | 34·37 | 3·80 | 3·52 | 3·63 |
| 30·5 | 29·3 | 30·1 | 24·3 | 24·1 | 24·2 | 8·55 | 8·30 | 8·45 | 34·90 | 34·52 | 34·77 | 3·92 | 3·52 | 3·75 |
| 29·3 | 28·0 | 28·7 | 24·6 | 23·4 | 23·8 | 8·40 | 8·30 | 8·35 | 35·25 | 33·45 | 33·98 | 4·7 | 4·2 | 4·53 |
| 29·9 | 28·0 | 29·45 | 24·3 | 24·2 | 24·30 | 8·45 | 8·1 | 8·3 | 35·5 | 34·86 | 34·99 | 4·75 | 4·25 | 4·51 |
| 30·2 | 26·5 | 27·87 | 24·7 | 24·3 | 24·6 | 8·6 | 8·2 | 8·45 | 35·41 | 35·33 | 35·39 | 4·90 | 4·00 | 4·40 |
| 29·1 | 26·8 | 27·8 | 24·8 | 24·3 | 24·60 | 8·6 | 8·45 | 8·50 | 35·9 | 35·30 | 35·43 | 4·80 | 3·49 | 3·94 |
| 28·8 | 27·0 | 28·1 | 25·0 | 29·8 | 24·83 | 8·6 | 8·45 | 8·54 | 35·59 | 34·92 | 35·26 | 6·84 | 4·23 | 4·96 |
| 28·7 | 26·0 | 27·9 | 24·6 | 24·5 | 24·52 | 8·6 | 8·1 | 8·5 | 35·08 | 32·07 | 33·40 | 5·79 | 4·18 | 4·84 |
| 28·0 | 27·5 | 27·8 | 24·0 | 23·8 | 23·9 | 8·1 | 8·1 | 8·1 | 33·31 | 32·16 | 32·55 | 5·04 | 4·60 | 4·89 |
| 27·2 | 26·0 | 26·45 | 24·0 | 23·7 | 23·7 | 8·5 | 8·3 | 8·4 | 33·63 | 32·15 | 32·95 | 5·47 | 5·18 | 5·40 |
| 27·5 | 27·0 | 27·2 | 23·0 | 23·0 | 23·0 | 8·5 | 8·3 | 8·40 | 33·59 | 32·84 | 33·31 | 4·86 | 4·75 | 4·78 |
| 28·5 | 28·2 | 28·3 | 23·2 | 23·2 | 23·2 | 8·5 | 8·4 | 8·43 | 33·82 | 33·53 | 33·60 | 5·14 | 4·67 | 4·86 |

TABLE 4.—*The excess base and nutrients of the Pearl Banks off Tuticorin during April 1960—March 1961.*

| *Excess base mg/L,* | | | *Calcium per gram atom/L,* | | | *Silicate—Silicon per gram atom/L,* | | | *Phosphate—Phosphorus per gram atom/L,* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX. | MIN. | AVER. | MAX. | MIN. | AVER. | MAX. | MIN. | AVER. | MAX. | MIN. | AVER. |
| 70·5 | 70·0 | 70·2 | 11,200 | 10,600 | 10910 | 6·5 | 2·5 | 4·9 | 2·0 | Trace. | Trace. |
| 70·0 | 69·5 | 69·75 | 11,200 | 10,900 | 11030 | 12·5 | 4·5 | 8·9 | 3·5 | 2·0 | 2·6 |
| 70·5 | 69·5 | 70·0 | 12,200 | 11,710 | 12080 | 22·5 | 10·0 | 17·2 | 8·0 | 3·0 | 6·0 |
| 71·5 | 69·5 | 70·3 | 12,200 | 11,710 | 11,940 | 30 | 12·5 | 19·0 | 3·0 | Trace. | 1·3 |
| 71·5 | 70·5 | 70·8 | 12,690 | 10,500 | 11,520 | 25 | 6·2 | 11·8 | 5·5 | .. | 2·1 |
| 71·5 | 69·5 | 70·4 | 12,780 | 12,200 | 12,600 | 8·0 | 3·0 | 5·7 | 2·0 | .. | Trace. |
| 71·5 | 70·8 | 71·1 | 12,930 | 11,710 | 12,240 | 15·0 | Trace. | 5·4 | 1·5 | .. | 0·42 |
| 71·8 | 67·5 | 70·62 | 12,200 | 10,490 | 11,390 | 6·5 | 6·0 | 17·8 | 3·0 | .. | ·70 |
| 68·5 | 68·5 | 68·5 | 11,810 | 11,480 | 11,630 | 20 | 18 | 19 | 2·5 | .. | Trace. |
| 70·5 | 69·5 | 70·0 | 11,710 | 10,980 | 11,500 | 18·0 | Trace. | 7·0 | 3·0 | Trace. | Trace. |
| 70·5 | 69·5 | 70·30 | 12,110 | 10,740 | 11,620 | 80 | 28 | 49 | 6·0 | Nil. | 1·3 |
| 71·5 | 70·5 | 70·8 | 12,450 | 11,710 | 12,000 | 90 | 25 | 48 | 3·5 | .. | 1·0 |

# HYDROBIOLOGY AND FISHERIES OF THE ENNORE RIVER NEAR MADRAS FROM APRIL 1960 TO MARCH 1961.

BY

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The Ennore river estuary is situated about eleven miles north of Madras City. It is $1\frac{1}{2}$ miles long and 4 furlongs wide and 3–5 feet deep on the average. The Buckingham Canal runs through it. Its bottom is muddy with an admixture of sand. The sea opens into it by a bar which occasionally closes.

This estuary is a good source of fisheries, particularly of mullets and prawns. Extensive beds of the edible oyster, *Ostrea madrasensis*, also occur in it and the adjoining backwaters. Studies on the hydrobiology and fisheries of this water area are therefore being pursued regularly at the Fisheries Biological Station at Ennore. In this note the salient features of observations made during the period 1st April 1960 to 31st March 1961 are given.

The bar of the estuary remained open with the sea from the beginning of 4th November 1960 to the end of the year. There was a total rainfall of 42·15 inches during the year spread over six months, 27·29 inches being in October. The maximum humidity was 96 per cent in January and March and the minimum 51 per cent in June. It averaged 78 per cent in June and 93 per cent in March. The atmospheric temperature attained a maximum of 36·5°C in May and minimum of 24·0°C in November. The surface temperature of the estuary-water showed a corresponding fluctuation, the maximum being 35°C in June and minimum 23·5°C in November. Coinciding with this, the specific gravity was noted to increase to 1·028 in July and August and decrease to 1·000 in November. The pH ranged between 8·9 in May and 7·4 in November. Higher salinity of 39·32–46·7 parts per 1,000 was observed during the months when the estuary had no connection with the sea. The minimum salinity was 0·2 °/oo in November. Details are given in tables I and II.

Regular hauls of plankton were made from the estuary and analysed quantitatively and qualitatively. The sedimentation ranged from 1 to 500 cc per haul of 1 litre made in 20 minutes. The diatoms *Coscinodiscus* and *Rhizosolenia* were fairly common almost throughout the year. Among zoo-plankton, copepods and their nauplii were very common throughout the year. Larval prawns were noted from June to November in large numbers. Fish eggs were present in fair number from June to September. *Leucifer* appeared in April and November. Zoea and Megalopa larvae were noted in November, December and January. The fluctuation of 35 organisms on the whole is given in table III.

The trend of the fisheries of the estuary was interesting. The total landings during the year were about 255 tons. Mullets particularly *Mugil cephalus and M. dussumieri* formed the bulk of the catches, being about 40 per cent of the total catches. Cat fishes, Silver bellies (*Leiognatus spp*) horse mackerals, Gizzard shad, Whiting, *Etroplus*, *Therapon* and *Gerres* were the other main fisheries. *Chanos chanos*, *Elops saurus*, *Polynemus*, *Teuthis* and Jew fishes were present in smaller numbers almost throughout. Prawns and crabs wre present throughout the year, but only formed 5·0 and 2·5 per cent of the total catches. Statistical details are given in Table IV.

TABLE I—*Meteorological data for the year* 1960–61 (*Ennore*).

| *Month.* | *Atmospheric temperature °C.* | | | *Humidity per cent.* | | | *Atmospheric pressure, inches.* | | | *Rain inches.* |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Maximum.* | *Minimum.* | *Average.* | *Maximum.* | *Minimum.* | *Average.* | *Maximum.* | *Minimum.* | *Average* | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| April | 33·0 | 32·5 | 32·75 | 88 | 62 | 76 | 1·022 | 1·019 | 1·021 | Nil. |
| May | 36·5 | 29·0 | 32·75 | 86 | 62 | 74 | 1·010 | 1·008 | 1·009 | Nil. |
| June | 35·5 | 29·0 | 32·25 | 74 | 51 | 68 | 1·010 | 1·003 | 1·007 | 0.35 |
| July | 34·0 | 28·5 | 31·25 | 80 | 62 | 71 | 1·006 | 1·003 | 1·004 | 1·19 |
| August | 33·0 | 29·5 | 31·25 | 80 | 60 | 74 | 1·008 | 1·003 | 1·006 | Nil. |
| September | 35·0 | 26·5 | 30·75 | 93 | 65 | 79 | 1·008 | 1·004 | 1·006 | 7·69 |
| October | 37·0 | 28·0 | 30·5 | 89 | 68 | 78·5 | 1·025 | 1·007 | 1·020 | 5·24 |
| November | 32·0 | 24·0 | 28·0 | 95 | 59 | 77 | 1·020 | 1·010 | 1·015 | 27·29 |
| December | 29·5 | 24·5 | 27·0 | 93 | 67 | 81·5 | 1·016 | 1·014 | 1·015 | Nil. |
| January | 31·5 | 26·5 | 29·0 | 96 | 67 | 81·5 | 1·016 | 1·014 | 1·015 | Nil. |
| February | 32·0 | 26·5 | 29·25 | 91 | 76 | 83·5 | 1·014 | 1·009 | 1·012 | 0·39 |
| March | 32·5 | 28·5 | 30·5 | 96 | 90 | 93 | 1·015 | 1·009 | 1·012 | Nil. |

TABLE II—*Hydrography of Ennore Estuary* (1960–61).

| *Months.* | *Surface temperature °C.* | | | *Specific gravity.* | | | *PH value.* | | | *Salinity. p.p. 1000.* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Maximum.* | *Minimum.* | *Average.* | *Maximum.* | *Minimum.* | *Average.* | *Maximum.* | *Minimum.* | *Average* | *Maximum.* | *Minimum.* | *Average.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| April .. .. .. .. | 29·0 | 28·0 | 28·5 | 1·022 | 1·018 | 1·000 | 8·7 | 8·2 | 8·4 | 43·4 | 40·0 | 41·7 |
| May .. .. .. .. | 34·0 | 28·0 | 31·0 | 1·026 | 1·022 | 1·024 | 8·9 | 8·2 | 8·5 | 44·8 | 41·5 | 41·15 |
| June .. .. .. .. | 35·0 | 27·5 | 31·25 | 1·027 | 1·002 | 1·025 | 8·6 | 8·0 | 8·3 | 46·7 | 38·6 | 46·67 |
| July .. .. .. .. | 32·5 | 28·5 | 30·5 | 1·028 | 1·025 | 1·027 | 8·7 | 8·0 | 8·2 | 40·3 | 35·03 | 37·7 |
| August .. .. .. | 32·5 | 27·5 | 30·5 | 1·028 | 1·024 | 1·026 | 8·4 | 8·2 | 8·3 | 39·32 | 35·88 | 37·6 |
| September .. .. .. | 33·0 | 26·0 | 20·5 | 1·026 | 1·018 | 1·018 | 8·4 | 8·7 | 8·1 | 36·84 | 14·89 | 25·8 |
| October .. .. .. | 32·5 | 27·5 | 30·0 | 1·012 | 1·008 | 1·010 | 8·4 | 8·0 | 8·2 | 20·80 | 14·21 | 17·5 |
| November .. .. .. | 30·5 | 23·5 | 27·0 | 1·010 | 1·000 | 1·005 | 8·4 | 7·4 | 7·9 | 18·54 | 0·223 | 9·3 |
| December .. .. .. | 29·0 | 24·5 | 26·75 | 1·018 | 1·002 | 1·010 | 8·4 | 7·0 | 8·2 | 20·82 | 14·02 | 17·4 |
| January .. .. .. | 29·0 | 26·5 | 27·75 | 1·020 | 1·010 | 1·015 | 8·4 | 8·0 | 8·2 | 26·44 | 17·32 | 21·9 |
| February .. .. .. | 29·5 | 26·5 | 28·0 | 1·022 | 1·008 | 1·020 | 8·4 | 8·0 | 8·2 | 26·92 | 26·44 | 26·7 |
| March .. .. .. | 30·0 | 28·0 | 29·0 | 1·024 | 1·020 | 1·022 | 8·4 | 8·0 | 8·2 | 28·40 | 27·32 | 27·9 |

TABLE III—*Plankton report for the yea*ı 1960-61 (*Ennore Estuary*).

| | *Apr.* | *May.* | *June.* | *July.* | *Aug.* | *Sep.* | *Oct.* | *Nov.* | *Dec.* | *Jan.* | *Feb.* | *Mar.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phytopllankton—* | | | | | | | | | | | | |
| 1 Rhizosolenia .. .. | F | F | F | F | F | F | F | P | R | .. | S | .. |
| 2 Navicula .. .. | R | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 3 Asterionella .. .. | R | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 4 Chaetoceros .. .. | R | .. | .. | F | .. | .. | .. | .. | .. | .. | .. | R |
| 5 Coscinodiscus .. .. | .. | .. | F | .. | .. | .. | F | F | F | .. | F | F |
| 6 Thallassiothrix .. | .. | .. | .. | .. | .. | .. | .. | R | .. | .. | .. | .. |
| 7 Biddulphia .. | .. | .. | .. | .. | .. | .. | .. | R | .. | R | .. | R |
| 8 Oscillatoria .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | F | R |
| 9 F.W. Algal filament. | .. | .. | .. | .. | .. | .. | .. | R | .. | .. | F | R |
| *Zooplankton—* | | | | | | | | | | | | |
| 10 Foraminiferan shells. | R | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | R |
| 11 Ceratium .. .. | R | P | R | R | F | F | .. | .. | .. | F | .. | R |
| 12 Noctiluca .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | R |
| 13 Tintinnus .. .. | .. | F | F | F | C | F | .. | F | F | F | S | S |
| 14 Rotifers .. .. | P | S | C | R | S | .. | .. | .. | .. | F | P | R |
| 15 Medusoids .. .. | .. | .. | .. | .. | R | F | F | .. | .. | .. | .. | .. |
| 16 Pleurobrachia .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | S |
| 17 Prototrochophore .. | .. | .. | .. | .. | R | .. | .. | .. | .. | F | .. | R |
| 18 Metatrochophore .. | .. | .. | F | F | F | .. | .. | .. | .. | .. | .. | .. |
| 19 Polychæte larvæ .. | R | .. | F | .. | .. | F | .. | R | P | P | R | R |
| 20 Larval Bivalves .. | F | .. | .. | .. | .. | .. | S | F | F | F | F | .. |
| 21 Larval Gastropods .. | F | F | P | P | P | C | C | F | .. | .. | .. | .. |
| 22 Nauplii .. .. | F | R | P | F | C | P | P | S | F | F | F | F |
| 23 Ostracods .. .. | .. | .. | .. | .. | F | .. | .. | .. | .. | .. | .. | .. |
| 24 Copepods .. .. | C | S | S | S | S | S | S | S | S | S | C | F |
| 25 Leucifers .. .. | R | .. | .. | .. | .. | .. | .. | C | .. | .. | .. | .. |
| 26 Mysis .. .. .. | R | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 27 Isopods .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | R | .. |
| 28 Amphipods .. .. | .. | .. | .. | .. | .. | .. | .. | R | .. | F | F | .. |
| 29 Young prawns .. | .. | R | C | S | S | S | S | S | R | R | .. | R |
| 30 Zoea larvæ .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | C | .. | R |
| 31 Megalopa larvæ .. | .. | .. | .. | .. | .. | .. | .. | C | C | .. | .. | R |
| 32 F.W. Insects .. .. | .. | .. | .. | .. | .. | .. | .. | .. | R | .. | .. | .. |
| 33 Oikopleura .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | R | .. | .. |
| 34 Fish eggs .. .. | R | .. | F | F | C | F | .. | .. | .. | .. | .. | R |
| 35 Larvae of fishes .. | R | .. | .. | .. | .. | .. | .. | R | .. | R | .. | .. |

NOTE.– R=10–30 individuals per CC ; F=30–200 per CC ; C=200 400 per CC ; P=400-1,030 per CC ; and S=More than 1,000 per CC.

TABLE IV— *Fishery Statistics of the Ennore Estuary for the year 1960-61.*

| *Month.* | *Mullet.* | *Gerres.* | *Sillago.* | *Therpon.* | *Caranx.* | *Chanos.* | *Equula.* | *Hemir amphus.* | *Etroplus.* | *Catfish.* | *Scolopsis.* | *Priacanthus.* | *Chatoessus.* | *Engraulis.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| April .. .. .. | 8,480 | 4,000 | 4,492 | 4,246 | 6,246 | 2,000 | 4,246 | 6,488 | 4,200 | 4,292 | 2,130 | 4,250 | 6,500 | 3,800 |
| May .. .. .. | 6,310 | 640 | 562 | 470 | 5,364 | 492 | 2,692 | 2,600 | 2,764 | 4,038 | 1,640 | 3,220 | 4,772 | 1,000 |
| June .. .. .. | 21,200 | 1,309 | 5,115 | 800 | 1,309 | 775 | 2,311 | 197 | 218 | 1,233 | 615 | 736 | 424 | 1,194 |
| July .. .. .. | 18,650 | 3,230 | 2,037 | 3,068 | 3,039 | 2,050 | 3,198 | 2,260 | 2,076 | 6,460 | 2,900 | 2,230 | 2,200 | 2,086 |
| August .. .. .. | 6,442 | 3,000 | 4,221 | 2,325 | 4,226 | 2,800 | 3,426 | 4,988 | 3,000 | 5,638 | 3,254 | 2,376 | 5,639 | 1,195 |
| September .. .. | 8,090 | 2,673 | 2,863 | 2,500 | 3,545 | 1,876 | 1,160 | 2,033 | 3,900 | 3,874 | 2,545 | 2,045 | 4,690 | .. |
| October .. .. | 62,546 | 418 | 280 | 4,100 | 5,090 | 1,120 | 11,250 | 520 | 216 | 8,286 | 1,418 | 2,196 | 2,243 | 3,548 |
| November .. .. | 22,000 | 232 | 236 | 286 | .. | .. | 2,692 | 250 | 200 | 3,500 | 189 | 2,190 | .. | 960 |
| December .. .. | 21,563 | 200 | 2,350 | 70 | .. | 450 | 2,300 | 185 | 450 | 2,955 | 200 | 1,169 | 1,300 | 1,150 |
| January .. .. | 12,830 | 250 | 2380 | 2,112 | 5,080 | 1,126 | 5,750 | 1,000 | 1,868 | 3,075 | 760 | 2,000 | 3,200 | 1,460 |
| February .. .. | 18,000 | 2,500 | 1,887 | 1,456 | 1,950 | 650 | 2,190 | 425 | 2,230 | 2,920 | 420 | 1,324 | 1,500 | 210 |
| March .. .. .. | 12,950 | 1,625 | 924 | 389 | 6,432 | 1,075 | 2,360 | 820 | 968 | 2,867 | 756 | 1,583 | 2,364 | 1,326 |
| | 2,19,061 | 20,077 | 27,347 | 21,822 | 41,281 | 14,412 | 43,675 | 21,766 | 22,085 | 49,138 | 16,827 | 25,310 | 34,832 | 17,919 |

| *Month.* | *Pristopoma.* | *Polycanthus.* | *Sciaena.* | *Teuthis.* | *Lutjanus.* | *Engraulis.* | *Elops.* | *Polynemus.* | *Flat fish.* | *Ambassis.* | *Miscl.* | *Prawn.* | *Crab.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (16) | (17) | (18) | (19) | (20) | (21) | (22) | (23) | (24) | (25) | (26) | (27) | (28) |
| April .. .. .. | 2,480 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2,094 | 4,312 | 1,700 |
| May .. .. .. | 2,040 | .. | .. | 1,960 | .. | .. | .. | .. | .. | .. | 1,390 | 4,764 | 1,600 |
| June .. .. .. | 675 | .. | .. | 1,310 | .. | .. | .. | .. | .. | .. | 1,206 | 946 | 953 |
| July .. .. .. | 3,183 | 2,065 | 2,070 | .. | .. | .. | 1,250 | .. | .. | .. | 2,860 | 2,215 | 3,048 |
| August .. .. .. | 2,876 | .. | 3,889 | .. | .. | 3,021 | .. | .. | .. | .. | 210 | 4,892 | 689 |
| September .. .. | 1,720 | 525 | 2,000 | 521 | .. | .. | 2,640 | 937 | .. | .. | 1,246 | 3,546 | 1,730 |
| October .. .. | .. | 2,060 | 2,200 | 1,066 | .. | .. | 1,085 | .. | 10 | .. | 2,064 | 1,400 | 50 |
| November .. .. | .. | 100 | 360 | .. | .. | .. | 180 | 550 | 95 | 629 | .. | 2,676 | 1,778 |
| December .. .. | .. | .. | 245 | 665 | 100 | .. | 200 | 300 | .. | .. | 500 | 465 | 54 |
| January .. .. | 1,850 | .. | 1,050 | .. | .. | .. | 569 | .. | .. | .. | 1,500 | 3,846 | 500 |
| February .. .. | 915 | 564 | 790 | .. | 422 | 366 | 400 | .. | 150 | .. | 920 | 1,060 | 379 |
| March .. .. .. | .. | 1,732 | 1,935 | .. | 1,100 | .. | 1,750 | .. | 883 | .. | 736 | 1,685 | 547 |
| | 15,739 | 7,946 | 14,539 | 4,922 | 1,622 | 3,381 | 8,074 | 1,787 | 1,138 | 629 | 14,966 | 31,807 | 14,068 |

# SIZE AND SEX COMPOSITION OF CATCHES OF THE LOBSTER PANULIRUS DASYPUS (LATREILLA) ALONG KANYAKUMARI DISTRICT COAST IN 1960-61.

BY

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## Introduction.

An account of the fishery of the lobster occurring in the coastal waters of Kanyakumari district has been given by Balasubramanyan (1960) and Ramanadan & Chacko (1962). The fishery of that rocky dwelling crustacean is lucrative to the local fisherfolk as the lobster 'Tails' are deep frozen and exported to the United States of America. In 1960–61, the fishery started in the second week of December 1960 and lasted till the end of March 1961. During the period about 400,000 lobsters were captured. The sex and size composition of these were studied as given below :—

## Sex Composition.

The details of the composition is given in Table I. Males predominated being 60·44 per cent when compared to 39·56 per cent of females. Almost all males were adults and only 1·36 per cent among them were immature. Of the females, 94·08 per cent were adults and 5·94 per cent were immature ; and 53·14 per cent were "berried" and 54·39 per cent possessed sperm-packets. Thus there was intensive spawning during the period.

## Size Composition.

The details of the size composition are given in Table II. The size groups, based on the length of the carapace were from 5–12 cm. of which 6—8 cm. groups constitute the bulk of the fishery. Males were represented in all the size groups, sizes 10–12 cm. being all males. On the contrary, females were confined to 5–9 cm. groups and they being totally absent in the higher size groups.

## Discussions.

The fishery in 1960–61 was slightly better than in 1959–60, when the total number of lobsters fished was only between 3 to 4 lakhs. However, mature individuals in stages of breeding continued to contribute to the bulk of the fisheries. These features may have an adverse effect on the future fisheries of these important Crustaceans. This aspect is however being watched by the Department.

## Acknowledgment.

I am thankful to Sri P. I. Chacko, Assistant Director of Fisheries, for his guidance and for his valuable suggestions.

## References.

Balasubramanyan, R., A. V. V. Satyanarayana and K.A. Sadanandan, 1960. A preliminary account of the experimental rocky-lobster fishing conducted along the south-west coast of India with bottom-set gill nets. *Indian Journal of Fisheries, VII*, 2, 407–422.

Ramanadan, R and P. I. Chacko (1962). A preliminary report on the lobster fishery of Kanyakumari District coast. *Fisheries Station report and year book, April* 1957–*March* 1958, *Madras Fisheries Department*, Pages 86–93.

Table I—*Showing sex composition of Lobsters caught during* 1960–61.

| | *Percentage in total number examined.* | *Percentage in total number of particular sex.* |
|---|---|---|
| Male lobsters .. .. | 60·44 | .. |
| Male adults .. .. | 59·62 | 98·63 |
| Male immature .. .. | 0·82 | 1·37 |
| Female lobsters .. .. | 39·56 | .. |
| Female adults without berry or sperm packet. | 10·90 | 27·26 |
| Female berried .. | 21·26 | 53·14 |
| Female with sperm packet. | 21·76 | 54·39 |
| Female with sperm packets and without berries. | 5·02 | 12·54 |
| Female immature.. .. | 2·38 | 5·94 |
| Female adult including berried ones. | 37·18 | 94·06 |

Table II—*Showing composition of different size groups (Carapace length) of Lobsters caught during* 1960–61.

| | | *Percentage of males,* | | *Percentage of females.* | | | |
|---|---|---|---|---|---|---|---|
| *Size group, cm.* (1) | *Percentage of group in total examined.* (2) | *Adults.* (3) | *Immature.* (4) | *Berried.* (5) | *With sperm packets.* (6) | *Adult without berried or sperm packets.* (7) | *Immature.* (8) |
| 5 .. .. .. | 7·71 | 39·65 | 1 | 0·6 | 0·12 | 17·75 | 30·77 |
| 6 .. .. .. | 22·95 | 51·09 | 2 | 18·4 | 14·80 | 23·6 | .. |
| 7 .. .. .. | 36·86 | 56·68 | .. | 31·1 | 32·25 | 6·43 | .. |
| 8 .. .. .. | 24·36 | 68·00 | .. | 21·5 | 21·91 | 6 ·18 | .. |
| 9 .. .. .. | 6·16 | 89·00 | .. | 6·60 | 5·90 | 4·44 | .. |
| 10 .. .. .. | 1·87 | 100·00 | .. | .. | .. | .. | .. |
| 11 .. .. .. | 0·04 | 100·00 | .. | .. | .. | .. | .. |
| 12 .. .. .. | 0·045 | 100·00 | .. | .. | .. | .. | .. |

# PISCIVOROUS BIRDS OF MADRAS

BY

H. K. GHAZI.

This list includes piscivorous birds, oceanic birds, shore birds, aquatic birds and predators and other birds which feed on fishes and other aquatic forms generally or occasionally.

*Class—Aves.*

*Sub-class—Neornithes.*

*Order—Podicipediformes.*

*Family—Podicipedidae.*

*Podiceps ruficollis capensis.*

*Order—Procellariiformes.*

*Family—Procellariidae.*

Daption capensis.
Procellaria leucomelaena.
Procellaria carneipes.
Procellaria pacifica chlororhyncha.
Procellaria tenuirostris.
Procellaria lherminieri bailloni.
Procellaria lherminieri persica.

*Order—Pelecaniformes.*

*Family—Phaethontoidae—*

Phaethon aethereus indicus.
Phaethon rubricauda rubricauda.
Phaithon lepturus lepturus.

*Family—Pelecanidae—*

Pelecanus onocrotalus roseus.
Pelecanus philippensis philippensis.

*Family Sulidae—*

Sula dactylartra melanops.
Sula sula rubripes.
Sula leucogasher plotus.

*Family—Phalacrocoracidae—*

Phalacrocorax carbo sinensis.
Phalacrocorax fuscicollis.
Phalacrocorax niger.
Anhinga rufa melanogaster.

*Family—Fregatidae—*

*Fregata andrewsi.*
*Fregata miner oldabrensis.*
*Fregata ariel iredalei.*

*Order—Ciconiiformes.*

*Family—Ardeidae—*

Ardea goliath.
Ardea cinerea rectirostris.
Ardea purpurea manilensis.
Buteroides striatus javanicus.
Ardeola grayii.
Bubulcus ibis coromandus.
Egretta alba modesta.
Egretta intermedia intermedia.
Egretta garzetta garzetta.
Egretta gularis schistacea.
Nycticorax nycticorax nycticorax.
Garsachius melanophus melanophus.
Ixobrychus cinnamomeus.
Ixobrychus sinensis sinensis.
Dupeter flavicollis flavicollis.
Botaurus stellaris stellaris.

*Family-Ciconiidae—*

Ibis leucocephalus.
Anastomus ascitans.
Ciconia episcopus episcopus.
Ciconia ciconia ciconia.
Ciconia nigra.
Xenorhynchus asiaticus asiaticus.
Leptoptilos dubius.
Leptoptiles javanicus.

*Family Threskiornithidae—*

Threskiornis melanocephala.
Pseudibis papillosa papillosa.
Plegadis falcinellus falcinellus.
Platalea leucordia major.

*Family—Phoenicopteridae—*

Phoenicopterus roseus.

*Order—Anseriformes.*

*Family—Anatidae—*

Anser anser rubrirostris.
Anser indicus.
Dendrocygna javanica.
Dondrocygna bicolor.
Tadorna ferruginea.
Anas acuta.
Anas crecca crecca.
Anas poecilorhyncha poecilorhyncha.
Anas strepera strepera.
Anas penelope.

Anas querquedula.
Anas clypeata.
Rhodonessa caryophyllacea.
Netta ruffina.
Aythya ferina.
Aythya nyroca.
Aythya fuligula.
Nettapus coromandelianus coromandelianus.
Sarkidiornis melanotos melanotos.

*Order—Falconiformes.*

*Family—Accipitridae—*

Elanus caeruleus vociferus.
Aviceda jerdoni ceylonensis.
Aviceda leuphotes leuphotes.
Aviceda leuphotes syama.
Pernis ptilorhynchus orientalis.
Pernis ptilorhynchus ruficollis.
Milvus migrans govinda.
Haliastur indus indus.
Accipter badius dussumieri.
Accipiter badius badius.
Accipiter trivirgatus peninsulae.
Accipiter nisus nisosimilis.
Accipiter virgatus besra.
Buteo vulpinus vulpinus.
Buteo buteo burmanicus.
Butastur teesa.
Spizaetus vipalensis Kelaarti.
Spizaetus cirrhatus cirrhatus.
Spizaetus cirrhatus ceylanensis.
Nisaetus fasciatus fasciatus spiza.
Heiraaetus pennatus.
Lophotriorchis Kienerii Kienerii.
Aquila clanga.
Aquila impalensis impalensis.
Aquila pomarina hastata.
Ictinaetus malayensis perniger.
Haliaeetus leucogaster.
Icthyophaga icthyaetus icthyaetus.
Icthyophaga icthyaetus plumbeiceps.
Tergos calvus.
Gyps indicus indicus.
Gyps bengalensis.
Neophron percnopterus gingionianus.
Circus cyaneus cyaneus.
Circus macrourus.
Circus pygarus.
Circus melanoleucos.
Circus aeruginosus aeruginosus.
Circaetus gallicus gallicus.
Spilornis cheela melanotis.
Spilornis cheela spilogaster

*Family—Falconidae—*

Falco biarmicus jugger
Falco peregrinus japonensis
Falco peregrinus peregrinator
Falco severus rufipedoides
Falco chiquera chiquera
Falco vespertinus amurensis
Falco naumanmi pekinensis
Falco tinnunculus tinnunculus
Falco tinnunculus interstinctus
Falco tinnunculus objurgatus

*Order—Gruiformes.*

*Family — Gruidae—*

Grus grus lilfordi
Grus antigone antigone
Anthropoides virgo

*Family—Rallidae—.*

Rallus aquaticus indicus
Rallus striatus albivanter
Rallina eurizonoides amauroptera.
Porzana pusilla pusilla
Porzana porzana
Amaurornis fuscus zeylonicus
Amaurornis akoolakool
Amaurornis phaenicurus chinensis
Amaurornis phoenicurus phoenicurus
Gallicrex cinerea cinerea
Gallinula chloropus indica
Porphyrio porphyrio poliocephalus
Fulica atra atra

*Family—Otididae—*

Chloriotis nigriceps
Sypheotides indica

*Order—Chardriiformes.*

*Family—Jacanidae—*

Metopidius indicus

*Family—Haematopodidae—*

Haematopus ostralegus ostralegus

*Family — Charadriidae—*

Vehellus leucurus
Vanellus gregarius
Vanellus indicus indicus
Vanellus malabaricus
Pluvialis squatarola
Pluvialis dominica fulva
Charadrius leschenaultii leschenaultii
Charadrius melanops
Charadrius asisaticus asiaticus
Charadrius dubius curonicus
Charadrius dubius jerdoni
Charadrius alexandrinus alexandrinus
Charadrius alexandrinus seebohmi
Charadrius monogolus atrifrons
Numenius phaeopus phaeopus
Numenius arquata arquata
Numenius arquata orientalis
Limosa limosa limosa
Limosa lapponica lapponica

Tringa erythropus
Tringa totanus totanus
Tringa totanus eurhinus
Tringa stagnatilis
Tringa nebularia
Tringa ochropus
Tringa glareola
Tringa terek
Tringa hypoleucos hypoleucos
Arenaria interpres interpres
Limnodromus semipalmatus
Capella solitaria solitaria
Capella nemoricola
Capella stenura
Capella megala
Capella media
Capella gallinago gallinago
Capella minima
Scolopax rusticola rusticola
Colidris tenuirostris
Calidris albus
Calidris minutus
Calidris temminchii
Calidris subminutus
Calidris acuminatus
Calidris testaceus
Limicola falcinellus falcinellus
Limicola falcinellus sibirica
Philomachus pugna
Phalaropus lobatus

*Family—Rostratulidae—*

Rostratula benghalensis benghalensis

*Family—Recurvirostridae—*

Himantopus himantopus himantopus
Recurvirostra avosetta

*Family—Dromadidae—*

Dromas ardeola

*Family—Burhinidae—*

Burhinus oedicnemus indicus
Esacus magnirostris recuruirostris

*Family—Glareolidae—*

Cursorius coromandelicus
Cursorius bitorquatus
Glareola pratincola pratincola
Glareola pratincola maldivarum

*Family—Stercororiidae—*

Catharacta skua antarctica
Catharacta skua lennbergi
Stercorarius Pomarinus

*Family—Laridae—*

Larus argentatus heuglini
Larus argentatus mongolicus
Larus fuscus fuscus
Larus icthyaetus
Larus brunnicephalus
Larus ridibundus ridibundus
Chlidonias hybrida indica
Chlidonias leucoptera
Gelochelidon nilotica nilotica
Hydroprogne caspia caspia
Sterna hirundo hirundo
Sterna hirundo tibetana
Sterna dougallii Kerustes
Sterna repressa
Sterna sumatrana sumatrana
Sterna acuticauda
Sterna anaethetus anaethetus
Sterna anaethetus antarctica
Sterna fuscata nubilosa
Sterna albifrons albifrons
Sterna albifrons saundersi
Sterna albifrons pusilla
Sterna bergi velox
Sterna bengalensis bengalensis
Anous stolidus pileatus
Anous tenuirostris worcesteri
Gygis alba monte
Rhynohops albicollis

*Order—Strigiformes.*

*Family—Strigidae—*

Bubo zeylonensis leschenault
Bubo zeylonensis zeylonensis
Strix leptogrammica indranee

*Order—Coraciiformes.*

*Family—Alcedinidae—*

Ceryle rudis leucomelanura
Ceryle rudis travancoreensis
Alcedo atthis taprobana
Alcedo meningting coltaorti
Alcedo meningting phillipsi
Ceyx erithacus erithacus
Pelargopsis capensis capensis
Halcyon coromanda coromanda
Halcyon smyrnensis fusca
Halcyon pileata

*Order—Passeriformes.*

*Family—Corvidae—*

Corvus splendens splendens
Corvus splendens protegatus
Corvus macrorhynchos levaillanti
Corvus macrorhynchos culminatus.

# OCCURRENCE OF THE ISOPOD FISH PARASITE, CYMOTHOA INDICA IN THE ADYAR FISH FARM, MADRAS.

BY

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## Introduction.

The Model Estuarine Fish Farm at Adyar consists of a lagoon which joins the Adyar river on its northern bank, close to its mouth, across which a regulator has been constructed. The reservoir so formed supplies water to a series of nurseries, breeding ponds, rearing ponds and marketing ponds. The whole farm covers an area of 55·4 acres. Several species of fish such as *Chanos chanos*, *Megalops cyprinoides*, *Tilapia mossambica* *Etroplus suratensis*, *Elops indicus* and Prawns such as *Penaeus indicus* and *Penaeus carinatus* have been stocked in the rearing ponds and observations made on their growth, breeding and other habits.

*Tilapia mossambica*, the recently imported African Cichlid fish which breeds and multiplies rapidly and grows to a fairly large size in fresh water was introduced in some of the rearing ponds on 30th December 1959. One hundred and twenty five Tilapia along with 500 Megalops cyprinoides were stocked in an area of one-sixth acre.

## Observations on Parasite on Tilapia.

In August 1960, *Cymothoa indica*, an *Isopod parasite* recorded by Panikkar and Aiyar (1937) on the Cichlids (*Etroplus maculatus* and *Etroplus suratensis*), the Gobids (*Glossogobius guiris* and *Acentrogobius viridipunctatus*) and the cat fish (*Macrones sp*) in the Adyar backwaters, was commonly found infesting the mouth cavity of *Tilapia mossambica* but not infesting *Megalops cyprinoides* which was in the same tank. The parasites were found singly or in pairs and when found in pairs consisted of a large female and a small male.

The following table shows the percentage of *Tilapia* infested with the parasites in various months.

| *Month.* | *Date of observation.* | *Percentage of fish infested.* |
|---|---|---|
| 1960— | | |
| August .. | 20th August 1960 .. | 22 |
| September .. | 24th September 1960 .. | 38 |
| October .. | 27th October 1960 .. | 32 |
| November .. | 30th November 1960 .. | 18 |
| December .. | 21st December 1960 .. | Nil. |
| 1961— | | |
| January .. | 28th January 1961 .. | 7 |
| February .. | 18th February 1961 .. | 2 |
| March .. | 18th March 1961 .. | 3 |
| April .. | 26th April 1961 .. | Nil. |
| May .. | 31st May 1961 .. .. | 6 |
| June .. | 28th June 1961 .. .. | Nil |
| July .. | 22nd July 1961 .. .. | Nil |
| August .. | 24th August 1961 .. | 33 |

The Hydrological conditions in the various months are as follows:—

| *Month.* (1) | *Water tempe-rature. °C.* (2) | *Specific gravity.* (3) | *Turbidity. cm.* (4) | *Salinity per cent.* (5) | *Oxygen cc/1.* (6) | *Carbon dioxide p.p.m.* (7) | *Silicates Mg/1.* (8) | *P.H.* (9) | *Depth feet inches.* (10) |
|---|---|---|---|---|---|---|---|---|---|
| 1960— | | | | | | | | | |
| August .. .. .. .. | 29·5 | 1·020 | 46·0 | 36·2 | 4·34 | Nil. | 64·9 | 8·4 | 5 10 |
| September .. .. .. | 28·0 | 1·021 | 60·00 | 28·5 | 4·60 | 2·0 | 41·6 | 8·4 | 6 6 |
| October .. .. .. .. | 28·0 | 1·020 | 65·75 | 26·20 | 4·27 | Nil. | 21·5 | 8·2 | 5 6 |
| November .. .. .. | 26·0 | 1·010 | 97·75 | 6·6 | 4·75 | Nil. | 19·0 | 8·2 | 6 0 |
| December .. .. .. .. | 26·0 | 1·010 | 81·25 | 16·25 | 4·34 | 1·0 | 13·0 | 8·2 | 4 9 |
| 1961— | | | | | | | | | |
| January .. .. .. .. | 26·9 | 1·010 | 84·5 | 23·14 | 3·98 | 1·0 | 11·0 | 7·8 | 4 3 |
| February .. .. .. .. | 27·5 | 1·012 | 94·0 | 25·31 | 4·06 | 1·0 | 21·5 | 8·0 | 4 2 |
| March .. .. .. .. | 28·0 | 1·012 | 100·5 | 30·94 | 6·09 | Nil. | 28·975 | 8·2 | 4 0 |
| April .. .. .. .. | 29·0 | 1·020 | 93·5 | 35·53 | 3·90 | Nil. | 46·6 | 8·4 | 4 0 |
| May .. .. .. .. | 30·0 | 1·020 | 112·5 | 32·10 | 2·43 | Nil. | 28·83 | 8·0 | 4 2 |
| June .. .. .. .. | 29·0 | 1·016 | 103·0 | 32·9 | 4·00 | Nil. | 28·10 | 8·0 | 4 10½ |
| July .. .. .. .. | 28·0 | 1·018 | 108.0 | 30·25 | 4·11 | Nil. | 18·50 | 8·2 | 5 3 |
| August .. .. .. .. | 29·0 | 1·014 | 78·5 | 28·62 | 3·85 | 2·5 | 8·0 | 8·3 | 4 11 |

The Hydrological conditions such as water temperature, specific gravity, turbidity, salinity, silicates, pH and depth are at their highest in the months of August, September and October. It is during these months that young *Gymothoa* are found in the plankton at the rate of one to three per cubic centimetre. Brood pouches of adults are found with fully developed larvae, larvae partly shed or larvae completely shed, indicating the beginnings of the free-living life of the parasite. In November, when the monsoon is in full sway, salinity is at its lowest. Depth of water is high but Specific gravity, Turbidity, Silicates and PH are all decreasing. The percentage of fish attacked also decreases. This may be due to the death of the adults after shedding of the larvae, induced by changing hydrological conditions. The Hydrological conditions continue to be low in December and January. Young parasites are in search of hosts and fresh infection is found to take place at this time. Old parasites disappear almost completely. From February onwards, hydrological readings show a gradual rise. Young Cymothoans, females of which have developing brood pouches are a common feature of fish that have been attacked. By March, Cymothoans with eggs in brood sac are available and in the following months various stages of the embryos can also be seen in the brood sacs. The very large drop in the percentage attacked from December onwards is partly due to the removal of parasites from the fish whenever they were available.

Details of *Cymothoa indica* examined from *Tilapia mossambica* from the rearing ponds and from the reservoir are as follows:—

| *Serial number.* (1) | *Length of Tilapia in mm.* (2) | *Sex.* (3) | *Gonadial condition (stage).* (4) | *Weight of Tilapia in grms.* (5) | *Length of parasite in mm. Female.* (6) | *Breadth of parasite in mm. Female.* (7) | *Length of parasite in mm. Male.* (8) | *Breadth of parasite in mm. Male.* (9) | *Remarks.* (10) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Date—20th August 1960. | | | | | |
| 1 | 141 | F | IV | 55 | 22 | .. | .. | .. | Brood sac empty. Flesh grown around claws. |
| 2 | 147 | F | IV | 85 | 15 | .. | 6 | .. | Brood sac developing. |
| 3 | 145 | F | IV | 70 | 17 | .. | .. | .. | Brood sac with larvae. |
| 4 | 170 | M | I | 110 | 22 | .. | .. | .. | Brood sac empty. |
| 5 | 147 | F | V | 80 | 16 | .. | 8 | .. | Brood sac with larvae. Flesh grown around claws in male and female. |
| 6 | 140 | F | IV | 80 | 16 | .. | 6 | .. | Brood sac developing. |
| 7 | 148 | F | IV | 85 | 20 | .. | .. | .. | Brood sac with larvae. |
| 8 | 110 | F | IV | 47 | 16 | .. | 8 | .. | Brood sac empty |
| 9 | 118 | F | IV | 55 | 20 | .. | .. | .. | Brood sac with larvae. *Tilapia* had bred. Those with and without parasites had gonads in advanced stages of development. |
| | | | | Date—24th September 1960. | | | | | |
| 10 | 150 | F | II | 95 | 17 | .. | .. | .. | .. |
| 11 | 149 | M | I | 90 | 19 | .. | .. | .. | .. |
| 12 | 150 | M | I | 130 | 17 | .. | .. | .. | .. |
| 13 | 155 | F | V | 100 | 17 | 9 | .. | .. | Flesh around claws. |
| 14 | 146 | F | V | 80 | 19 | .. | 6 | .. | .. |
| | | | | Date—27th October 1960. | | | | | |
| 15 | 160 | F | IV | 75 | 19 | .. | .. | .. | .. |
| 16 | 176 | M | IV | 95 | 21 | .. | .. | .. | .. |
| 17 | 175 | F | IV | 110 | 19 | .. | .. | .. | .. |
| 18 | 165 | F | IV | 75 | 17 | .. | .. | .. | .. |
| 19 | 158 | F | IV | 65 | 16 | .. | 9 | .. | Brood sac empty. |
| 20 | 160 | F | IV | 75 | .. | .. | 12 | .. | .. |
| 21 | 155 | F | IV | 60 | 18 | .. | 13 | .. | Brood sac empty |
| 22 | 138 | F | III | 40 | 20 | .. | 10 | .. | Brood sac empty. |
| | | | | Date—30th November 1960. | | | | | |
| 23 | 140 | F | .. | 45 | 16 | .. | 12 | .. | .. |
| 24 | 167 | F | .. | 75 | 16 | .. | .. | .. | .. |
| 25 | 162 | F | .. | 65 | 18 | .. | .. | .. | .. |
| 26 | 155 | F | .. | 65 | .. | .. | 14 | .. | .. |
| | | | | Date—28th January 1961. | | | | | |
| 27 | 145 | F | .. | 80 | 21 | .. | 9 | .. | .. |
| 28 | 163 | F | .. | 75 | 19 | .. | [illegible] | .. | .. |

| Serial number. (1) | Length of Tilapia in mm. (2) | Sex. (3) | Gonadial condition in mm. of stage. (4) | Weight of Tilapia in grams. (5) | Length of parasite in mm. (Female.) (6) | Breadth of parasite in mm. (Female.) (7) | Length of parasite in mm. (Male.) (8) | Breadth of parasite in mm. (Male.) (9) | Remarks. (10) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Date—18th February 1961. | | | | | |
| 29 | 136 | M | .. | 65 | 22 | .. | 10 | .. | .... |
| | | | | Date—18th March 1961. | | | | | |
| 30 | 155 | F | .. | 85 | 18 | .. | .. | .. | .... |
| | | | | Date—31st May 1961. | | | | | |
| 31 | 147 | M | .. | 30 | 22 | .. | .. | .. | .... |
| | | | | Date—24th August 1961. | | | | | |
| 32 | 122 | M | .. | 50 | 16 | .. | 3 | .. | 429 developing embryos in early stage—Tongue reddish. |
| 33 | 107 | F | .. | 52 | 14 | .. | .. | .. | Bleeding during removal of parasite. |
| 34 | 145 | M | .. | 30 | 20 | .. | 8 | .. | .... |
| | | | | Date—3rd January 1962. | | | | | |
| 35 | 150 | F | .. | .. | .. | .. | 5 | 2 | From 3rd January 1962 onwards. Tilapia examined are from reservoir. |
| | | | | Date—6th February 1962. | | | | | |
| 36 | 149 | M | .. | .. | 4 | 1·5 | 8 | 3 | .... |
| 37 | 145 | M | .. | .. | 14 | 7 | 5 | 2 | .... |
| | | | | | | | 6 | 2·5 | Three males in one. |
| | | | | | | | 3 | 1 | .... |
| 38 | 139 | M | .. | .. | .. | .. | 5 | 2 | .... |
| 39 | 133 | M | .. | .. | .. | .. | 5 | 2·5 | .... |
| 40 | 140 | M | .. | .. | 12 | 5 | 6 | 2 | Two males in one. |
| | | | | | | | 4 | 1·5 | .... |
| 41 | 105 | F | .. | .. | 9 | 3 | .. | .. | .... |
| 42 | 124 | F | .. | .. | .. | .. | 5 | 2 | Two males in one. |
| | | | | | | | 5 | 1·5 | |
| | | | | Date—8th February 1962. | | | | | |
| 43 | 143 | M | .. | .. | 11 | 4 | 5 | 3 | *Zoothamnium* found on Cymothoans. |
| | | | | | .. | .. | 5 | 3 | .... |
| 44 | 135 | M | .. | .. | .. | .. | 5 | 2·5 | .... |
| 45 | 149 | M | .. | .. | 11 | 4 | 5 | 2 | One male found on gills, 2 males and 2 females in one. |
| 46 | 149 | M | .. | .. | 5 | 2·5 | 4 | 1·5 | |
| | | | | | 9 | 4 | 6 | 3 | .... |
| 47 | 139 | F | .. | .. | .. | .. | 7 | 2·5 | .... |
| 48 | 147 | M | .. | .. | 12 | 6 | 5 | 2 | Eggs in brood sac. |
| 49 | 124 | F | .. | .. | 7 | 3 | 6 | 2·5 | Two males. |
| 50 | 137 | M | .. | .. | | | 5 | 1·5 | |
| | | | | | 12 | 5 | 4 | 1·5 | Two females. |
| 51 | 126 | M | .. | .. | 4 | 2 | | | |
| | | | | | 9 | 4 | .. | .. | .... |
| 52 | 145 | M | .. | .. | 11 | 5 | .. | .. | .... |
| 53 | 123 | M | .. | .. | 5 | 2 | 5 | 1·5 | Male found outside behind eye. |
| 54 | 124 | F | .. | .. | | | | | |
| | | | | Date—20th February 1955. | | | | | |
| 55 | 150 | M | .. | .. | 15 | 5 | 5 | 1·5 | Hairs on Uropod lost in male. |
| | | | | | 7 | 3 | 3 | 1·0 | Male has characters of larva and adult. |
| 56 | 150 | M | .. | .. | 6 | 3 | | | |
| | | | | | 11 | 5·5 | 7 | 3·5 | .... |
| 57 | 153 | M | .. | .. | 7 | 3 | 4·5 | 2 | .... |
| 58 | 155 | M | .. | .. | .. | .. | 2 | 1 | Has characters of both larva and adult of. |
| 59 | 157 | M | .. | .. | | | | | |

The marketing ponds of the farm and the reservoir contain several species of fish the main varieties being *Mugil sp. Chaetossus nasus, Leiognathus sp., Gerres sp., Caranx sp., Serranus sp., Engraulis sp., Stolephorus sp., Sillago sihama, Therapon sp., Scatophagus sp., Teuthis java* and *Hemirhampus sp.* But *Cymothoa indica* was found on *Etroplus suratensis, Macrones gulio, Gobius giuris*, *Polynemus tetradactylus, Pomodasys hasta* and *Sphyraena obtusata*, but not on the other species. Next to *Tilapia mossambica*, infection was heavy on *Macrones gulio.* Infection of *Etroplus suratensis* and *Gobius giuris* ranked third in the order. The three other species were rarely available and it was interesting to note that some of the others obtained were also infected.

Particulars of parasitic infection on the other species of fish are given below :—

### I. *Macrones gulio.*

| *Serial number.* | *Length of Macrones in mm.* | *Length of parasite in mm. (Female.)* | *Breadth of parasite in mm. (Female.)* | *Length of parasite in mm. (Male.)* | *Breadth of parasite in mm. (Male.)* | *Remarks.* |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Date—6th February 1960. | | | | | | |
| 1 | 57 | .. | .. | .. | .. | With parasite. |
| Date—6th December 1960. | | | | | | |
| 2 | 83 | .. | .. | 4·5 | .. | .... |
| Date—18th February 1961. | | | | | | |
| 3 | 93 | .. | .. | 10·0 | .. | .... |
| 4 | 118 | 22 | .. | .. | .. | .... |
| 5 | 110 | 18 | .. | .. | .. | .... |
| Date—24th August 1961. | | | | | | |
| 6 | 126 | 15 | .. | 7 | .. | 355 eggs in brood sac. |
| Date—25th August 1961. | | | | | | |
| 7 | 93 | 11 | .. | 6 | .. | .... |
| 8 | 113 | 12 | .. | 2 | .. | .... |
| 9 | 91 | 10 | .. | 6 | .. | .... |
| 10 | 83 | 10 | .. | 4·5 | .. | .... |
| Date—26th August 1961. | | | | | | |
| 11 | 113 | 13 | .. | 8 | .. | .... |
| Date—28th August 1961. | | | | | | |
| 12 | 90 | 8 | .. | .. | .. | .... |
| Date—29th August 1961. | | | | | | |
| 13 | 114 | .. | .. | 9 | .. | 14 per cent covered with *Zoothamnium.* |
| 14 | 113 | .. | .. | 5 | .. | Eyes very clear. |
| 15 | 118 | .. | .. | 9 | .. | Partly covered with *Zoothamnium.* |
| 16 | 110 | 14 | .. | 7 | .. | .... |
| 17 | 94 | 9 | .. | .. | .. | *Zoothamnium*, light green and feathery. |
| 18 | 101 | 13 | .. | 8 | .. | Both partly covered with *Zoothamnium.* |
| 19 | 90 | 7 | .. | .. | .. | .... |
| 20 | 79 | 5 | .. | .. | .. | With *Zoothamnium.* |
| Date—30th August 1961. | | | | | | |
| 21 | 80 | .. | .. | 8 | .. | .... |
| Date—31st August 1961. | | | | | | |
| 22 | 136 | .. | .. | 5 | .. | .... |
| 23 | 117 | 17 | .. | 4 | .. | .... |
| 24 | 83 | 7 | .. | .. | .. | .... |
| Date—4th September 1961. | | | | | | |
| 25 | 151 | .. | .. | .. | .. | With parasite. |
| 26 | 118 | .. | .. | .. | .. | Do. |
| 27 | 106 | .. | .. | .. | .. | Do. |
| 28 | 108 | .. | .. | .. | .. | Do. |
| 29 | 88 | .. | .. | .. | .. | Do. |

| *Serial number.* (1) | *Length of Macrones in mm.* (2) | *Length of parasite in mm. (Female.)* (3) | *Breadth of parasite in mm. (Female.)* (4) | *Length of parasite in mm. (Male.)* (5) | *Breadth of parasite in mm. (Male.)* (6) | *Remarks.* (7) |
|---|---|---|---|---|---|---|
| Date—6th September 1961. | | | | | | |
| 30 | 117 | 14 | .. | 9 | .. | Brood pouch with larvae. Some already shed. |
| Date—9th October 1961. | | | | | | |
| 31 | 152 | 9 | .. | .. | .. | With *Zoothamnium.* |
| 32 | 140 | 7 | .. | .. | .. | Do. |
| 33 | 135 | 15 | .. | 9 | .. | .... |
| Date—21st October 1961. | | | | | | |
| 34 | 135 | 16 | .. | 9 | .. | With *Zoothamnium,* |
| 35 | 88 | 11 | .. | 4·5 | .. | Do, |
| Date—27th October 1961. | | | | | | |
| 36 | 135 | 18 | .. | 9<br>4<br>8 | .. | One male on right side of mouth. Another on left. Third on gills. Larvae in brood pouch. |
| Date—31st October 1961. | | | | | | |
| 37 | 153 | 14 | 9 | 7 | 3 | .... |
| 38 | 114 | 9 | 4 | 5 | 2 | .... |
| 39 | 118 | 12 | 6 | 7 | 3 | .... |
| 40 | 114 | .. | .. | 2 | 1 | Male found behind gill slit. |
| Date—4th November 1961. | | | | | | |
| 41 | 129 | 16 | 9 | 7 | 4 | Eggs in brood sac. |
| 42 | 110 | .. | .. | 6 | 3 | .... |
| Date—8th December 1961. | | | | | | |
| 43 | 156 | 17 | 9 | .. | .. | Eggs in brood sac. |
| 44 | 137 | 17 | 9 | 8 | 3 | 344 eggs in brood sac, |
| 45 | 138 | 15 | 8 | 8 | 4 | With *Zoothamnium.* Larvae in brood pouch. |
| 46 | 129 | 10 | 4 | .. | .. | Brood pouch very small, |
| 47 | 111 | 14 | 7 | 7 | 3 | .... |
| Date—14th December 1961. | | | | | | |
| 48 | 135 | 15 | 8 | 8 | 3 | Eggs in brood pouch. Whitish growth of *Zoothamnium.* |
| Date—3rd January 1962. | | | | | | |
| 49 | 190 | 12 | 6 | 7 | 3 | .... |
| 50 | 97 | 11 | 5 | 5 | 2 | With *Zoothamnium.* |
| Date—8th February 1962. | | | | | | |
| 51 | 148 | 6 | 3 | 5 | 2 | Female on gill cover. |
| 52 | 168 | 10 | 5 | .. | .. | Found on gills. |
| Date—16th February 1962. | | | | | | |
| 53 | 100 | 8 | 4 | .. | .. | .... |
| 54 | 95 | 10 | 6 | .. | .. | .... |
| 55 | 83 | 10 | 6 | .. | .. | With eggs. |
| Date—16th February 1962. | | | | | | |
| 56 | 77 | 10 | 4 | .. | .. | ... |
| 57 | 91 | 11 | 6 | .. | .. | With eggs |
| 58 | 72 | 9 | 5 | 5 | 3 | Male on gills. |

| Serial number. (1) | Length of Gobius in mm. (2) | Length of parasite in mm. (Female.) (3) | Breadth of parasite in mm. (Female.) (4) | Length of parasite in mm. (Male.) (5) | Breadth of parasite in mm. (Male.) (6) | Remarks, (7) |
|---|---|---|---|---|---|---|
| *II. Gobius giuris.* | | | | | | |
| Date—6th February 1960. | | | | | | |
| 1 | 96 | .. | .. | .. | .. | With parasite. |
| 2 | 73 | .. | .. | .. | .. | Do. |
| Date—11th August 1960. | | | | | | |
| 3 | 256 | .. | .. | .. | .. | With parasite. |
| Date—21st April 1960. | | | | | | |
| 4 | 250 | .. | .. | .. | .. | With parasite. |
| Date—25th August 1960. | | | | | | |
| 5 | 113 | 11 | .. | 6 | .. | .... |
| Date—31st August 1961. | | | | | | |
| 6 | 190 | 20 | .. | 10 | .. | .... |
| 7 | 111 | .. | .. | 6 | .. | .... |
| Date—31st October 1961. | | | | | | |
| 8 | 173 | 20 | 11 | 9<br>8 | 4<br>.. | Second male on gill cover. |
| 9 | 146 | 13 | 6 | 6 | 2·5 | |
| 10 | 131 | 14 | 6 | 7 | 2·5 | .... |
| Date—3rd November 1961. | | | | | | |
| 11 | 210 | 20 | .. | 11 | 4 | Completely covered with black scum of *Zoothamnium.* Young in brood sac. |
| 12 | 162 | 18 | 8 | 9 | 4 | .... |
| 13 | 152 | 14 | 6 | .. | .. | .... |
| 14 | 144 | 15 | 5 | 7 | 3 | .... |
| Date—16th February 1962. | | | | | | |
| 15 | 120 | 15 | 5 | 8 | 3 | Male parasite seen for the first time facing inwards. |
| Date—17th February 1962. | | | | | | |
| 16 | 150 | .. | .. | .. | .. | Three parasites. One female with eggs. Two males. |
| Date—1st March 1962. | | | | | | |
| 17 | 119 | 15 | 7 | 8 | 4 | Eggs in brood sac. *Zoothamnium* on both. Male completely covered. |
| Date—2nd March 1962. | | | | | | |
| 18 | 126 | 12 | 5 | 6 | 3 | Eggs in brood sac. |
| 19 | 70 | 5 | 3 | .. | .. | .... |
| *III. Etroplus suratensis.* | | | | | | |
| Date—6th December 1960. | | | | | | |
| 1 | 82 | .. | .. | .. | .. | With parasite. |
| 2 | 33 | 4·5 | .. | 4·0 | .. | .... |
| 3 | 32 | .. | .. | .. | .. | With parasite. |
| 4 | 38 | .. | .. | .. | .. | Do. |
| 5 | 32 | .. | .. | .. | .. | Do. |
| 6 | 34 | .. | .. | .. | .. | Do. |

| *Serial number.* | *Length of Etroplus in mm.* | *Length of parasite in mm.* *Female.* | *Breadth of parasite in mm.* *Female.* | *Length of parasite in mm.* *Male.* | *Breadth of parasite in mm,* *Male.* | *Remarks.* |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | | | Date—24th August 1961. | | | |
| 7 | 118 | 16 | .. | 8 | .. | .... |
| 8 | 74 | 8 | .. | 5 | .. | ... |
| | | | Date—25th August 1961. | | | |
| 9 | 79 | 12 | .. | 5 | .. | ... |
| | | | Date—28th August 1961. | | | |
| 10 | 63 | 10 | .. | .. | .. | Covered with *Zoothamnium.* |
| | | | Date—26th October 1961. | | | |
| 11 | 97 | 14 | .. | 8 | .. | Larvae in brood sac. |
| | | | *IV. Polynemus tetradactylus.* | | | |
| | | | Date—22nd March 1960. | | | |
| 1 | 230 | .. | .. | .. | .. | With parasite. |
| | | | Date—28th April 1960. | | | |
| 2 | 250 | .. | .. | .. | .. | With parasite. |
| | | | Date—28th June 1960. | | | |
| 3 | 289 | .. | .. | .. | .. | With parasite. |
| | | | *V. Pomodasys hasta.* | | | |
| | | | Date—18th February 1961. | | | |
| 1 | 212 | .. | .. | .. | .. | With parasite. |
| | | | *VI. Sphyraena obtusata.* | | | |
| | | | Date—1st March 1962. | | | |
| 1 | 136 | 9 | 3·5 | 2 | 1 | .... |

*Cymothoa indica* is usually found singly or in pairs but sometimes there are three or four individuals on the same fish. When it is a single individual, the parasite is either a male or female more commonly a female. When in pairs, there is usually a large female attached to the tongue of the fish, while the smaller male fixes itself just behind or right at the back of the mouth towards one side. If one more male is present, it occupies the hind corner of the mouth on the opposite side. Sometimes a third male may be found on the gill-rakers, or gill covers or even on the head somewhere behind the eye. Both the male and female occupying the mouth, usually face the mouth opening. It was only on one occasion that a male parasite was found facing the gullet of the fish. Two females are sometimes found on the same fish, when the larger takes a central position.

The largest female parasite recorded is one of length 22 mm. The greatest width recorded is 11 mm. The length is usually more than double the width. The largest male recorded is 14 mm. long. The greatest width recorded is 4 mm. The male, at its largest is usually, just a little more than half the length of the female. It is commonly half the length of the female or smaller. The width of the male is half or less than half its own length.

The general body form of the adult female is obovate and reminds one of an inverted turnip with the fan like telson and uropods representing the leaves. The male body form is oval. The head and thorax together form the Cephalothorax. The head is about as long as it is broad and is partly sunk in the first segment of the thorax. It is narrow anteriorly and broadest posteriorly. The eyes are paired, sessile, large, compound, darkly pigmented and they extended downwards on either side of the head. They become less prominent with age. The appendages of the head consist of two pairs of antennae. The first pair consists of eight stout and large segments. It extends to the posterior margin of the head. The basal segments of the two are widely separated. The second pair of antennae consist of nine narrower and smaller segments each and also extend to the posterior margin. The basal segments are even more widely separated than the first. At the tip of the distal segment of each second antenna there are two very fine setae.

The mouth parts are specially modified for their parasitic mode of life and are best suited for piercing and sucking. There are a pair of maxillipeds, a pair of first maxilla, a pair of second maxilla and a pair of mandibles with three segmented palp.

The thorax is seven segmented. The first thoracic segment is longer than the second but not as wide. Its antero-lateral angles are acute and produced forwards to half the length of the head. The thoracic segments gradually widen out until it is widest at the fifth thoracic segment. After this the segments that follow are narrower. The length of the thoracic segments after the second gradually increase until it is longest at the fourth segment. The segments following this become shorter by stages. There are seven pairs of clawed thoracic appendages which are well adapted for their prehensile function. The first three pairs are short and of these the first is the shortest and the third the longest. The claws of these three pairs curve backwards. The remaining four pairs of thoracic appendages are longer than the first three and have the claws curved forwards in opposition to those of the first three pairs. All seven pairs of thoracic appendages are six segmented.

The abdomen is clearly differentiated from the thorax in that its segments are abruptly narrower and shorter than the thorax. It consists of six segments, the sixth segment being the broad fan-like telson which is slightly notched in the middle of its posterior margin. The abdominal appendages consist of 5 pairs of biramous pleopods which are broad, rounded and fan-like, a pair to each of the first five segments. The last segment, the telson, carries a pair of two-jointed, biramous Uropods, which are slightly shorter than the telson. The lamellar pleopods are both natatory and respiratory in function. The telson with uropods also helps in swimming. In males, the second pair of pleopods shows a modification of the Endopodite known as *Appendix masculina*. In females, *Marsupial plates*, eight in number are developed to form an incubatory pouch, on the ventral side of the thorax, extending between the thoracic appendages. The arrangement of these plates is very interesting. The posterior-most plate overlaps the hind ends of the foregoing pair of plates. The anterior-most plate is overlapped by the next pair of plates. The three central pairs of plates are overlapped at their posterior ends by the plate following and overlap anteriorly the foregoing plate. These plates are transparent and membranous. They are so closely packed in the early stages that it forms a tight compartment. As the eggs form within the brood pouch it takes a more convex appearance. At the time of shedding of the larvae, the plates are more loosely packed and an opening forms anteriorly between the anterior-most plate and the first pair of plates, by a spreading out of the plates to give more space.

In very early stages of the development of eggs in the brood pouch there are masses of yolk but with the outer membrane not yet formed. When the eggs are differentiated they are rounded with a large yellow yolk. They give the brood sac a lemon yellow colour as the plates are transparent. As development proceeds the egg lengthens out being broader towards the anterior end. The number of eggs or embryos in a brood sac varies, as shown below :—

| *Length of parasite mm.* | *Breadth of parasite mm.* | *Number of eggs or larvae.* | *Remarks.* |
|---|---|---|---|
| 12 | 7 | 143 | Eggs partly formed Rest as yolk pieces. |
| 15 | 7 | 629 | Eggs. |
| 15 | 9 | 443 | Eggs. |
| 15 | .. | 355 | Eggs. |
| 16 | .. | 429 | Developing embryo |
| 17 | 9 | 344 | Eggs. |
| 19 | 10 | 450 | Larvae. |
| 19 | 11 | 498 | Larvae. |

The eggs start forming when the parasite is about 10-12 mm. in length. The larvæ resemble the adult in their body consisting of a head, thorax and an abdomen with similar appendages on each segment. The difference lies in the fact that the appendages have their segments lengthened out so that the antennae, thoracic appendages, pleopods and uropods are all long and spread outwards. The eyes are large, well developed and clearly compound. In the early larval stages, hairs are absent on the appendages but in the later stages, the flattened pleopods, telson and uropods develop hairs which probably help in swimming in the free living pelagic life. Similarly fine, spiny processes develop in the various segments of the thoracic appendages especially the claws. This is probably to help in prehension when they chance to land upon a host during their pelagic life. The colour of the brood pouch changes from lemon yellow to dirty brown with the absorption of yolk and the formation of the larvæ. The colour of the larvæ is dirty brown giving the same colour to the pouch. The larvæ measure from 1 to 2 mm. in length and 0·5 mm. in width at this stage, the transitory stage, when the larvae leave the brood pouch, for their short free living life, before their parasitic life. They are very efficient and fast swimmers at this stage.

As the time for a parasitic life approaches the limbs shorten. The dorsal carpace slowly begins to harden and takes an arched appearance. The thoracic appendages which are spread out curve inwards so that when viewed dorsally they are first partly hidden and then completely drawn in. The pleopods which were linear become fan-like or lamellate, now more useful for respiration than for swimming, although they are still utilised for swimming also. The earliest stage at which they secure a host is at a length of 2 mm. and a width of 1 mm. The increase in breadth during this period is slow. Parasites 4 mm. long and 1·5 mm. broad still show larval characters. Hairs on uropods and pleopods remain and if they are put into water they swim well. The uropods are still longer than the telson. Stouter spines are found on the thoracic appendages, which have still to bend inwards completely.

When the parasite is 5 mm. long and 1·5 mm. broad and has settled down to a parasitic mode of life, it loses the hair on its pleopods, uropods and telson as they are no longer required. Thoracic appendages are completely drawn in. The stout spines become blunt projections. Powers of swimming are still present, though to a small degree. The male and female resemble each other but can be differentiated by their variation in shape. Their colour is dirty-white but they sometimes take on a blackish or a brownish tinge. Both the male and the female rest with their claws well embedded in the soft epithelium of the fishes' mouth. The telson is always tilted upwards to give enough, moving space for the pleopods below which are constantly vibrating, as a part of their function as respiratory organs. Both the male and the female produce enough irritation with their prehensile claws in the mouth epithelium of the fish so as to cause it to grow up around the tips of the claws themselves, when infestation has been for a long period. The parasite has to be plucked out to be removed, when there is bleeding and bits of flesh are found sticking to the claws. The place of attachment is found to be red and sore, the degree of injury being greater with a longer period of infestation. The parasite also loses its convex dorsal form with long infestation and becomes softer and flatter. The clear compound eyes of early parasitism gradually degenerate until there is only a faint reminescence of its former presence.

The early stages of parasitism are however temporary. Several parasites seem to get into the same fish but they do not seem to remain there for long. At the earliest opportunity they have to move out for a more suitable host. This is clearly understood from the fact that where several parasites are found they are usually young. It is more common to find the older ones either singly or in pairs. They are single probably when a male has still to find its way in. That the young parasites do move out when conditions are unfavourable is proved by observation. When a fish dies the very old parasites remain within and die with the fish whereas the young ones which are still capable of walking and swimming, creep out and get into the water. If a live fish is introduced into the water they immediately get on to it and try to get into the buccal cavity of the fish through the mouth. The fish resents the presence of the intruder and tries to get rid of the parasite as it climbs up, by vigorously shaking its head and swimming fast, but to no effect as the claws of the parasite take a firm grip of the fish.

Whether the parasite always gets into the buccal cavity through the mouth is not certain. In *Etroplus suratensis* the mouth is very small but we find large parasites within the buccal cavity which can be removed only by cutting open the sides of the mouth. The parasites can easily get in through the mouth during the free living stage when they are 1 mm. to 2 mm. in length but it is possible that they get in through the gill slits as individuals have been found on the gill rakers. Even in this case only very young parasites were found on the gills, as infection is usually during the early stage. When they try to get out after temporary infection they try to do so through the mouth opening which is nearest, but this is not possible in later stages, in the case of *Etroplus suratensis* which has a very small mouth.

Though the fish shows a dislike to the entry of the parasite, its presence does not seem to affect the fish seriously. Its presence in the mouth may prevent free entry of water and food. The injury caused by the penetrating claws of the parasite may cause discomfort. But the fish seems to get used to this in course of time.

That the body fluids are sucked up by the parasite is quite clear but large quantities of it could not possibly be taken in, as the parasite does not shift its position over a wide area. The body fluids lost do not seem to seriously affect its growth. The gonads are unaffected. Advanced stages of gonads are found in both parasitised fish and unaffected fish in the breeding period. Mechanical removal of the parasites from the fish affected, help to lessen the intensity of attachment. The fish are able to withstand the process of parasitic removal and there is cent per cent survival of the fish after this.

A common and interesting feature was to find both male and female parasites from a size of 4·5 mm. and over to be partly or wholly covered dorsally with a greenish, blackish or dirty white coating or scum, or with a light green, feathery, plant like growth. Microscopic examination revealed them to be colonies of the vorticellid, *Zoothamnium*. Jones and Job (1938) have noted an interesting case of animal association between brackish water fish *Accentrogobius neilli* and *Zoothamnium*, it being attached to the teeth of fish. In this case, suitable substratum for attachment is provided by the hard carapace of *Cymothoa indica*. Probably remnants of the fishes food serve as food of the *Zoothamnium*. This is a case of Commensalism with continuous contact, where the individual derives both food and shelter.

## Discussion.

*Cymothoa indica* is a typical parasite in that it lives in close contact with its host drawing nourishment from it but without causing its death. The parasite shows a preference for the fishes it selects. Young larvae of *Cymothoa indica* are set free from the brood pouches mainly in the months of August, September, October and November. In six months time, i.e., in March, April and May, these young parasites are mature with eggs completely formed in the brood pouch. Development of the eggs into larvae in the brood sac stretches over another six months. From August onwards eggs are again noticed in brood pouches which suggests two breeding periods during the year. The life span of an individual does not appear to be less than a year. But in the estuary and reservoir, where fish rarely survive over a year, as in summer, water level is very low and most of the fish are caught, the parasites do not get a chance of living to their maximum span of life.

## Acknowledgment.

Thanks are due to Sri A. J. Thangadurai, Laboratory Assistant, for giving the hydrological data of the pond under study.

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On a cymothoan parasite on some brackish water fishes from Madras. *Current Science* 8.

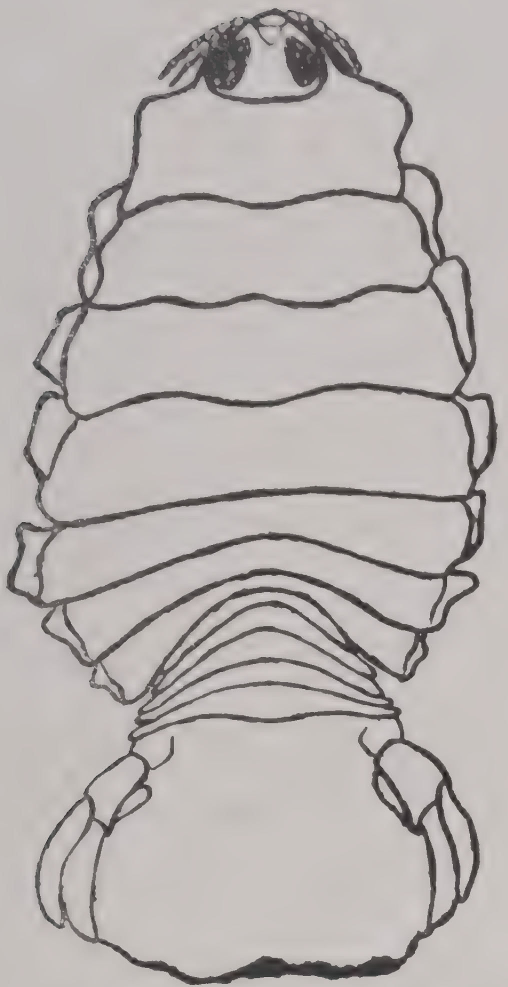

Fig. 1——Adult Female (Dorsal view).

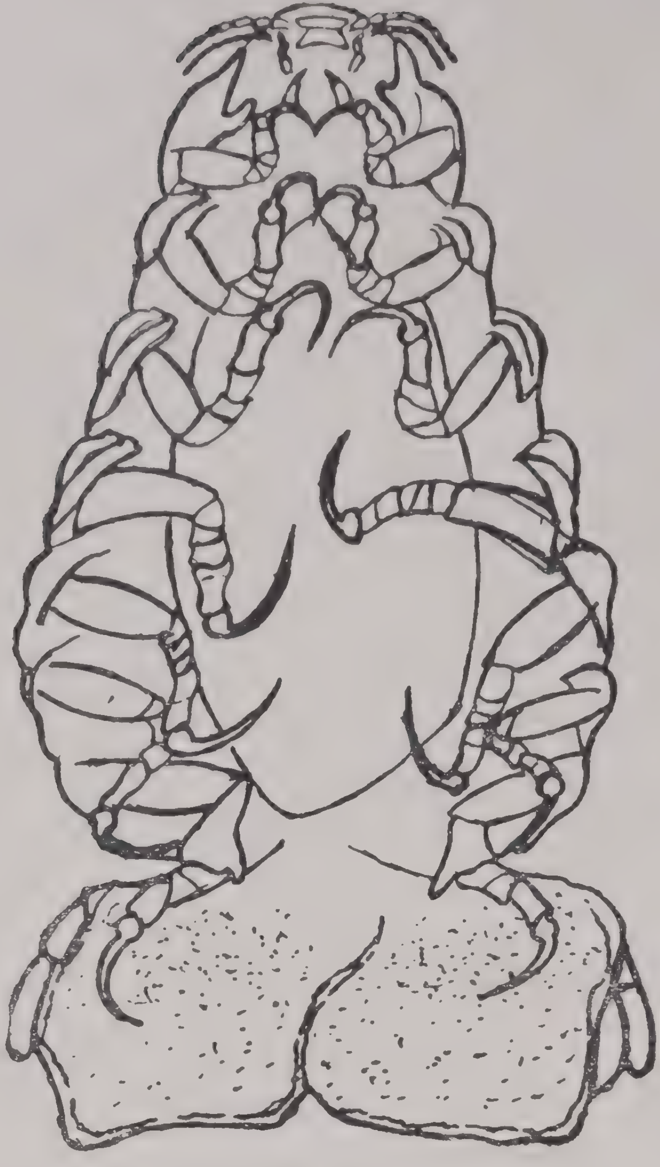

Fig. 2—Adult Female (Ventral view).

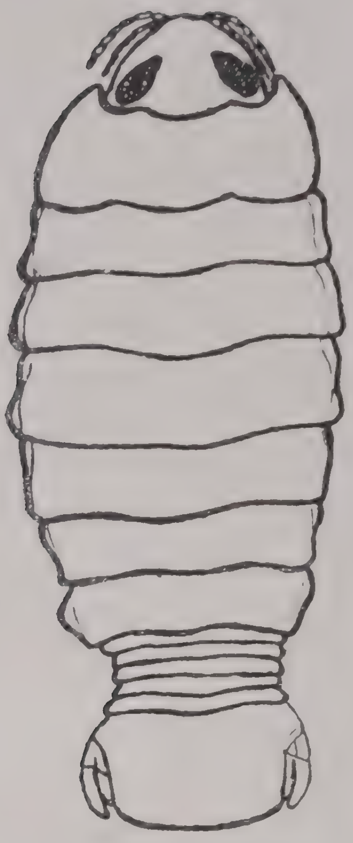

Fig. 3—Adult Male.

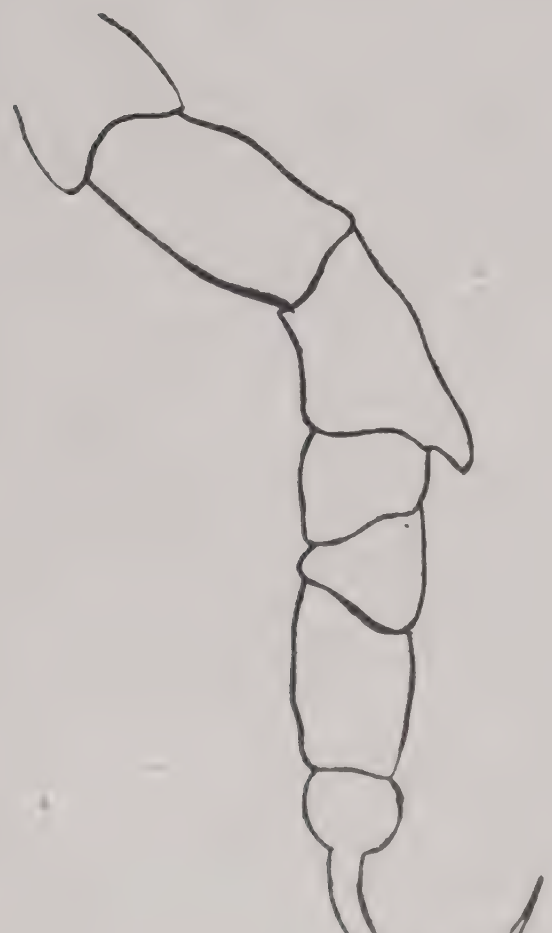

Fig. 4—Seventh Thoracic Leg (Female.)

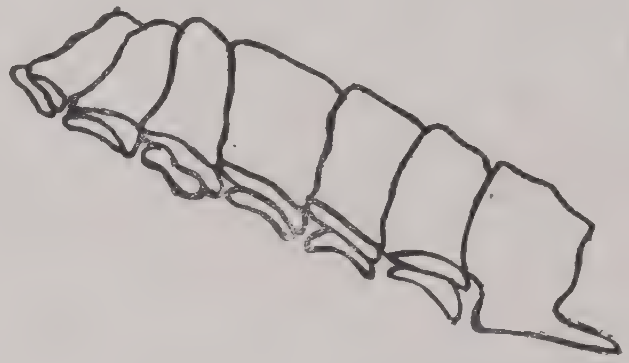

Fig. 5—Lateral view of Thorax of Adult Female.

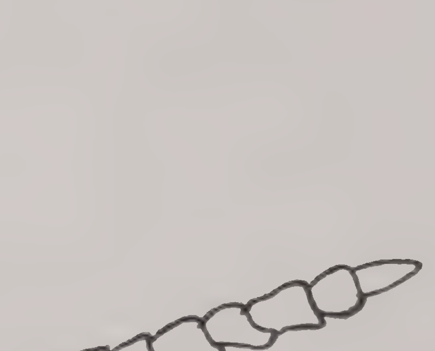

Fig. 6—First Antenne.

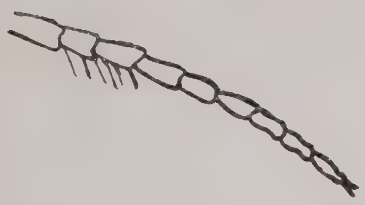

Fig. 7—Second Antenna.

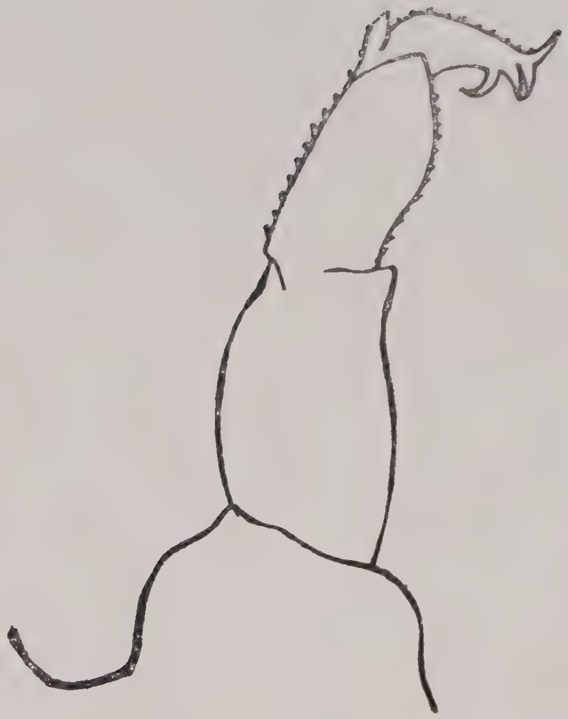

Fig. 8—Maxilliped.

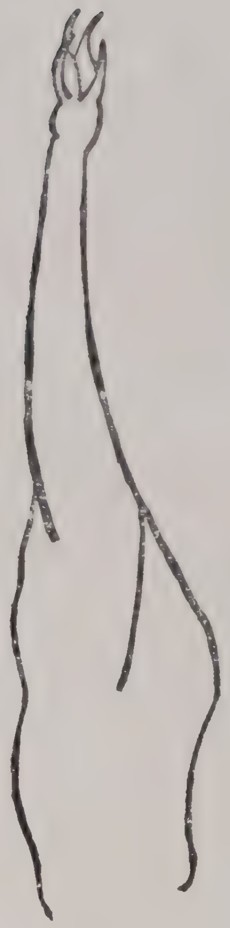

Fig. 9—First Maxilla.

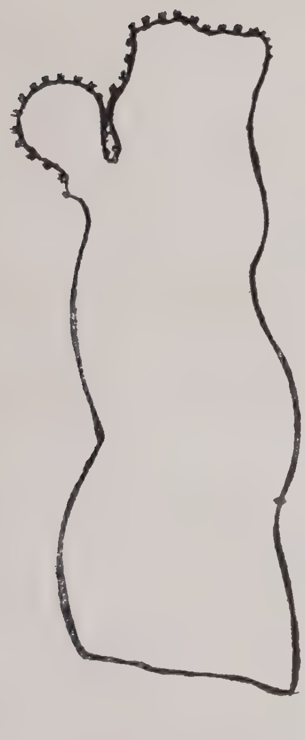

Fig. 10—Second Maxilla.

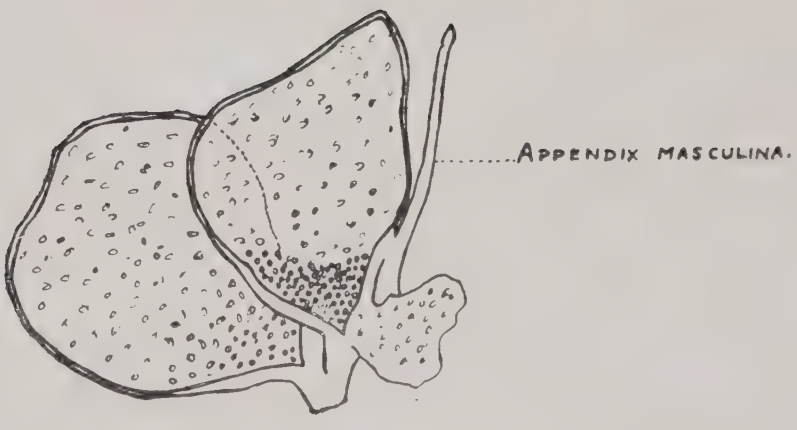

Fig. 11—Male Pleopod (Second).

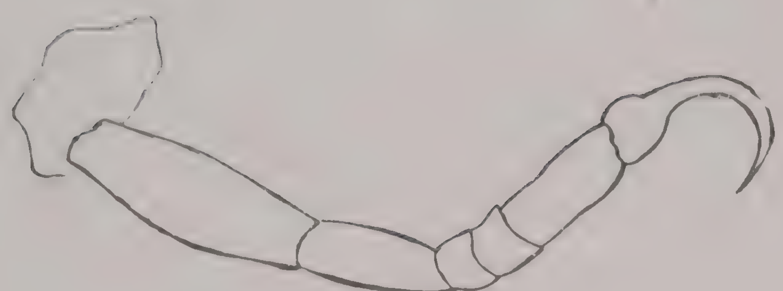

FIG. 12—Third Thoracic leg.

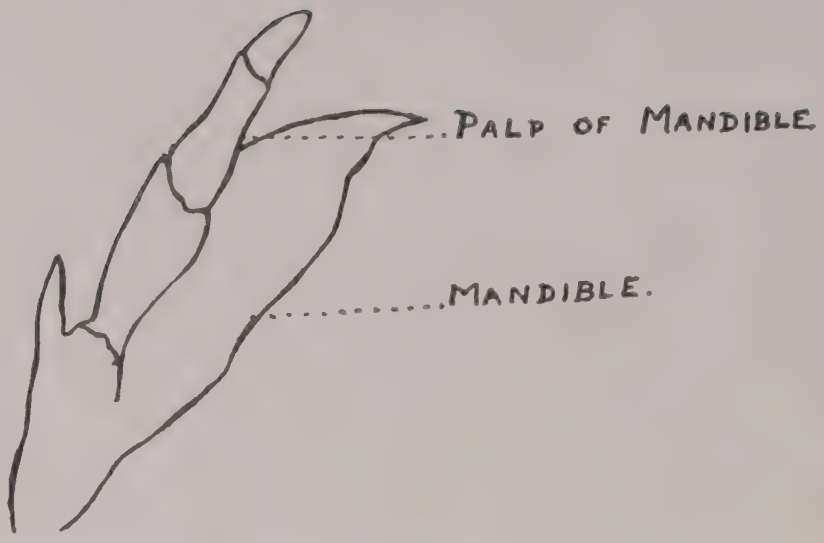

FIG. 13. Mandible with palp.

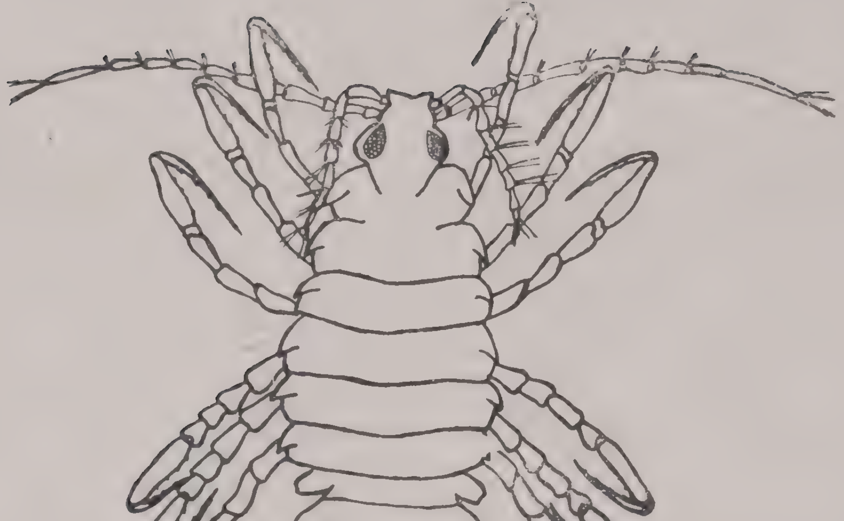

FIG. 14—Young of *Cymothoa indica* just before it leaves the broodpouch.

# AN UNUSUAL DRIFTING OF GLAUCUS MARINUS (Du Pont) FROM THE BAY OF BENGAL INTO THE ENNORE RIVER NEAR MADRAS.

BY

P. I. CHACKO AND A. RAJAGOPAL, MARINE BIOLOGICAL STATION, ENNORE.

*Glaucus marinus* (Mollusca, Gastropoda, Euthyneura, Opisthobranchiata, Nudibranchiata, Aeolidiidae), is a pelagic sea-slug occurring in the Bay of Bengal. It is about 30 to 50 millimetres in length; and is beautifully coloured with blue and purple tinges over a white background. It floats on its back in the sea with its blue ventral side upwards, thus correlating with light and shade of the marine environment. This habit enables it to get drifted with the currents and come into contact with other small soft-bodied pelagic animals to which it adheres. In this process its appendages and radula play an important part.

Though this sea-slug is thrown up along the Madras beach occasionally, an unusual instance of drifting of very large numbers of this animal into the Ennore river occurred in the month of December 1960. Cyclonic weather conditions prevailed from 24th to 27th day of the month. Several living and dead specimens of the Siphonophore, *Porpita pacifica* Lesson were washed ashore on the beach and also drifted into the Ennore river. But during the later hours of the 28th, there was an unusual drift from the sea towards the shore, and this threw a large numbers of *Glaucus marinus* into the river. On the 29th morning, the southern bank of the river estuary was found strewn with these dead sea-slugs in the form of a belt about one kilometre in length and one metre in width. On an average 200 individuals were counted in one square metre of the area.

It is likely that the depression and the consequent whirling that prevailed in the Bay of Bengal at that time would have caused an aggregation of these pelagic nudibranchs into a mass, which would have been brought towards the shore near Ennore by the north-east monsoonic drift and then cast into the river by the high tide. The less saline water (17·32 parts per thousand) of the river estuary would not have been conducive to the survival of the organisms. The temperature of the river water ranged from 25·0 to 25·5 °C during that period. The atmospheric temperature was 25·5–27·0°C, humidity 90–93 per cent, specific gravity of water 1·012–1·016 and pH 8·4. An instance of this nature has not been recorded before. However, this is a typical example indicating as to how weather and oceanographic conditions affect the life of marine organisms.

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# SWARMING OF THE CTENOPHORE, PLEUROBRACHIA GLOBOSA, MOSER IN THE ENNORE RIVER ESTUARY NEAR MADRAS.

BY

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The Comb-jelly, *Pleurobrachia globosa*, Moser (Phylum *Ctenophora*, Class *Tentaculata*, Order *Cydippida*) occurs in the Indian Ocean. It has been recorded by several workers from plankton collections made from the inshore waters of the Indian coast. Occasionally it gets drifted into estuaries and also gets washed along the beach. In the Ennore river estuary near Madras this Ctenophore is rarely met in the plankton collections. But an unprecedented swarming of this organism occurred here in the month of March 1961.

In the plankton collected from the estuary in the early hours of 4 a.m. on 21st March 1961, there was not even a single specimen of *Pleurobrachia globosa*. But when plankton was collected six hours later, that is, at 10 a.m., over 500 specimens of this Ctenophore were obtained in a tow-net haul of 10 minutes duration. The net was clogged and could be lifted only with difficulty. The other planktonic organisms in the collection were negligible and consisted of few diatoms (*Chaetoceros*, *Coscinodiscus* and *Biddulphia*), dinoflagellate (*Ceratium*), Cystoflagellate (*Noctiluca*), Copepods, nauplius larvae and Zoea Larvae. Eight hours still later (4 p.m. ) it was seen that the southern bank of the river was strewn with these Ctenophores in a thick mass to a length of about one kilometre. It was estimated that there were about 600 dead individuals per square metre on the average.

The sea was very rough on 20th and 21st of March 1961 and there was a large inflow of sea water into the estuary during high tide. It is evident that these Ctenophores got congregated in the ocean and were then drifted towards the coast and pushed into the river by the ocean currents and tide during the morning hours of 21st of March 1961.

The meteorological and hydrographical conditions of the estuary during the period, were as follows :—

| | |
|---|---|
| Atmospheric temperature | 28·5 °C. to 32·0°C. |
| Humidity | 94–96 per cent. |
| Surface temperature of estuary water. | 29·0 °C to 30·5°C. |
| Specific gravity of water | 1·020 to 1·022 |
| pH of water | 8·2. |
| Salinity of water | 28·34 to 28·40 p.p. 1000. |
| Oxygen content of water | 2·20 c.c./litre. |

These conditions were not suitable to the Ctenophores and therefore they did not survive in the estuary. Such a large scale mortality of this form has not been recorded before in the Madras area. As already explained the weather and oceanographic conditions were responsible for this peculiar incidence.

ICE CUM COLD STORAGES AT METTUR, TUTICORIN, NEELAN KARAI, CUDDALORE AND BHAVANI SAGAR.

# PROXIMATE CHEMICAL COMPOSITION OF MARINE FISHES

BY

P. JAYACHANDRAN, FISHERIES TECHNOLOGICAL STATION, TUTICORIN.

Many papers have been published on the nutritive values of the various food fishes both marine and inland Saha and Guha (1939), Basu and De (1938, 1938a), ***Niyogi et al*** (1941), *Setna et al* (1944), Chari (1948). The present paper gives the results of the study on nutritive value of some of the East Coast Marine Food Fishes as available in Tuticorin Bay.

## Methods.

Only the edible portion was taken into consideration for analysis of the nutritive values. Fins, scales, skeletal structures and viscera were removed and the flesh alone was analysed. However, in the case of small fishes, the whole fish was minced and the pulp analysed for proximate composition. The fish for analysis were purchased from the landing place and analysis were carried out on absolutely fresh fish.

A representative sample was obtained by thoroughly mincing about 5 to 10 fishes and mixing them well. Analysis were carried out for the determination of the following constituents, Moisture, Protein, Fat, Ash, $P_2 O_5$, Cao Iron and Copper. The moisture content was determined by drying a weighed sample of the minced pulp to a constant weight in a hot air oven at 100° C. The protein content was calculated by multiplying the total nitrogen, as determined by the Kjedahl distillation method by 6·25, ash by the Stolte's dry ashing method and fat by extracting the dried s ample withether for about 12 to 16 hours in a Soxhlet apparatus. The ash was further analysed for Phosphorus, Calcium, Iron and Copper. The ash was extracted with hydrochloric acid and made up to a known volume. Aliquots were pipetted out for determination of Phosphorus, Calcium, etc. Phosphorus was estimated by the Ammonium-Molybdate volumetric method (Burns—Hunderson 1935) Calcium by Mc. Crudden's Permanganate method, Iron was estimated according to the method of Elvehjam 1930—Kennedy 1927—Colorimetrically and copper using diethyl-dithio Carbonate.

The results of the analysis are given in Table I.

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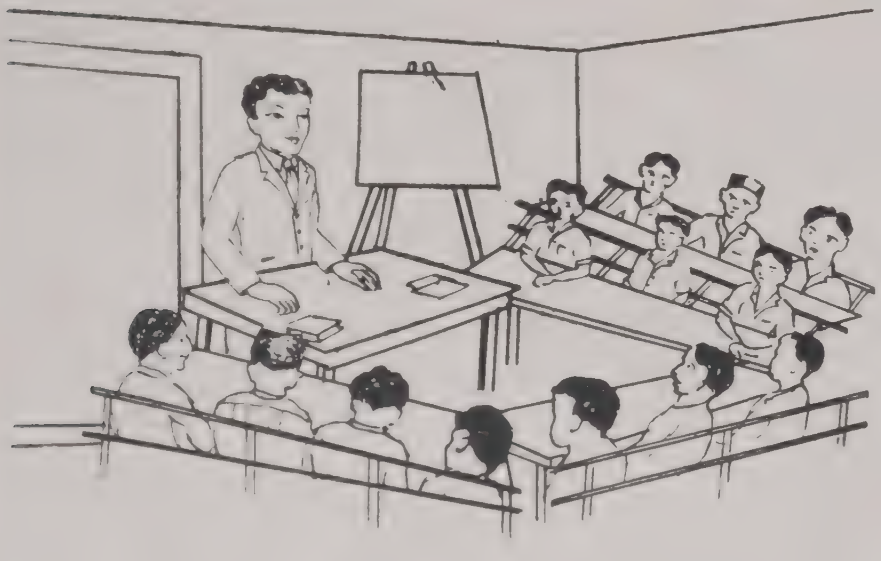
ANALYSIS OF

| *Serial number and Common English name.* (1) | *Scientific name.* (2) | *Average weight.* (3) GM. | *Average length.* (4) CM. | *Edible portion.* (5) PER CENT. |
|---|---|---|---|---|
| 1 Sardine | Sardinella sirm | 50 | 19 | 71·4 |
| 2 Slender shad | Ilisha elongata | 453 | 39 | 75·0 |
| 3 Sprat | Dussumieria acuta | 42 | 11·5 | 75·0 |
| 4 Wolf Herring | Chirocentrus dorab | 453 | 36 | 60·0 |
| 5 Lizard Fish | Saurida tumbil | 102 | 24 | 66·6 |
| 6 Gar Fish | Belone strongylura | 50 | 30 | 57·0 |
| 7 Barracuda | Sphyraena jello | 225 | 60 | 64·7 |
| 8 Cock up | Lates calcarifer | 900 | 46 | 56·0 |
| 9 Coral cod | Serranus miniatus | 1,001 | 36 | 55·5 |
| 10 Reef cod | Serranus undulosus | 453 | 32 | 62·5 |
| 11 Rock cod | Serranus pantherinus | 1,021 | 32 | 55·5 |
| 12 Silver Whiting | Sillago sihama | 113 | 24 | 75·0 |
| 13 Big Jawed Jumper | Lactarius lactarius | 128 | 21 | 44·4 |
| 14 Horse Mackerel | Caranx rottleri | 510 | 25 | 50·0 |
| 15 Malabar horse mackerel | Caranx malabaricus | 128 | 20 | 66·7 |
| 16 Black king fish | Elecate nigra | 910 | 40 | 75·0 |
| 17 Blue Lined snapper | Lutianus rivulatus | 1,134 | 38 | 45·0 |
| 18 Snapper | Lutianus spp. | 330 | 20 | 45·0 |
| 19 Silver belly | Leiognathus splendens | 34 | 12 | 60·0 |
| 20 Dusky surgeon fish | Acanthurus gahm | 142 | 21 | 60·0 |
| 21 Ribbon fish | Trichiurus savala | 41 | 41 | 88·0 |
| 22 Sole | Cynoglossus Semifasciatius | 150 | 31 | 80·0 |
| 23 Seer | Cybium guttatum | 353 | 39·5 | 70·80 |

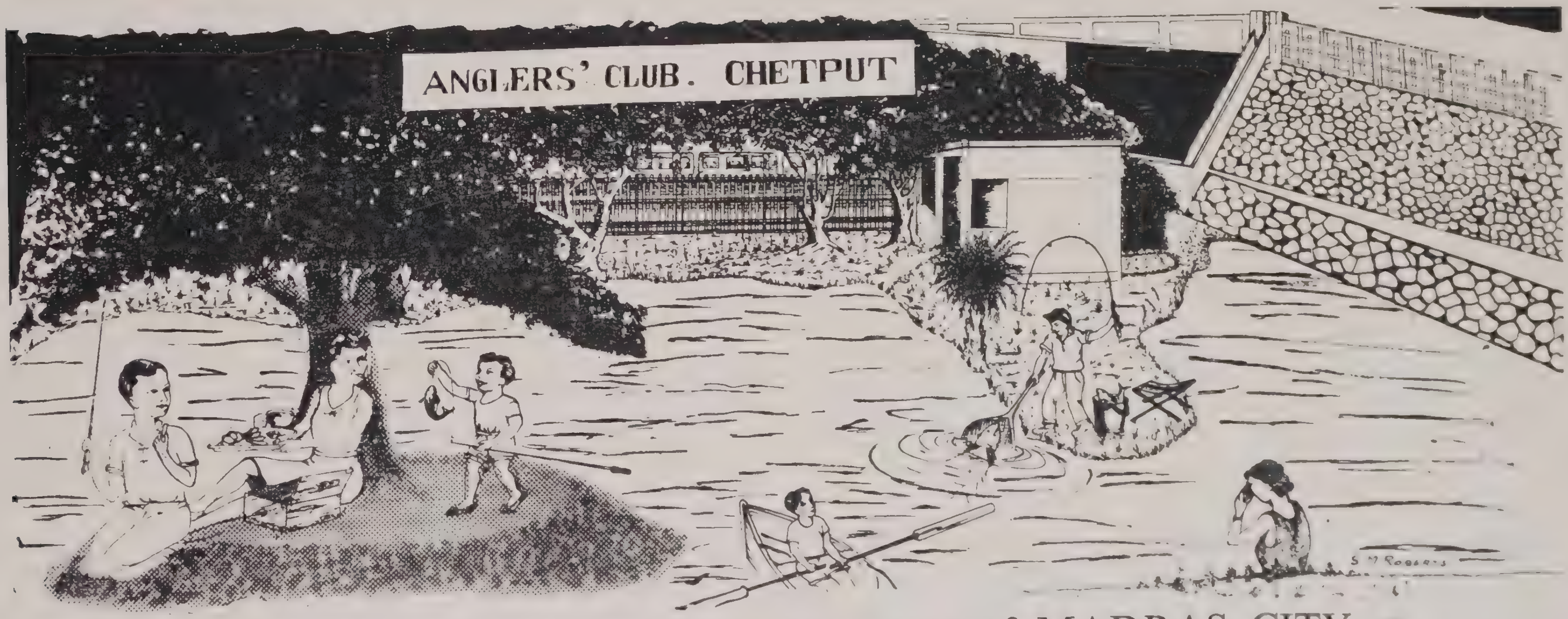


GOVT. FISHERIES TRAINING CENTRES.

MADRAS, TUTICORIN, NAGAPATTINAM
AND
METTUR.

FRESH FISH.

| $H_2O$ (6) PER CENT. | Protein. (7) PER CENT. | Fat. (8) PER CENT. | Ash. (9) PER CENT. | $P_2O_5$. (10) PER CENT. | Cao. (11) PER CENT. | Iron (12) Mg. PER 100 G. | Copper (13) Mg. PER 100 G. |
|---|---|---|---|---|---|---|---|
| 77·85 | 18·2 | 1·85 | 0·50 | 0·03 | 0·07 | 8·1 | 0·36 |
| 70·5 | 19·87 | 8·2 | 1·5 | 0·3 | 0·28 | 4·2 | 0·95 |
| 76·3 | 19·9 | 4·15 | 6·7 | 1·35 | 1·6 | 3·7 | 1·5 |
| 78·2 | 20·7 | 1·1 | 1·5 | 0·20 | 0·09 | 4·7 | 0·25 |
| 77·0 | 19·3 | 2·5 | 1·4 | 0·60 | 0·35 | 5·7 | 3·7 |
| 77·4 | 19·7 | 1·1 | 1·6 | 0·95 | 0·42 | 2·4 | 2·2 |
| 81·8 | 16·2 | 0·93 | 1·25 | 0·39 | 0·07 | 4·7 | 1·5 |
| 74·9 | 14·8 | 2·8 | 1·20 | 0·30 | 0·32 | 1·7 | 0·20 |
| 76·7 | 19·5 | 5·65 | 1·35 | 0·50 | 0·28 | 2·5 | 0·20 |
| 80·8 | 15·8 | 0·73 | 1·25 | 0·60 | 0·48 | 2·5 | 0·20 |
| 77·53 | 17·45 | 2·0 | 1·40 | 0·64 | 0·275 | 1·8 | 0·25 |
| 76·3 | 18·7 | 0·68 | 1·37 | 0·47 | 0·23 | 2·2 | 1·5 |
| 70·4 | 16·0 | 4·9 | 1·40 | 0·50 | 0·29 | 2·3 | 0·20 |
| 75·8 | 18·6 | 1·3 | 1·65 | 0·27 | 0·28 | 7·6 | 4·70 |
| 76·0 | 15·9 | 1·9 | 1·82 | 0·3 | 0·32 | 8·2 | 0·60 |
| 75·0 | 18·7 | 3·1 | 1·25 | 0·60 | 0·30 | 3·2 | 0·50 |
| 78·9 | 16·2 | 1·1 | 1·2 | 0·35 | 0·11 | 1·4 | ·15 |
| 78·0 | 16·1 | 1·65 | 1·50 | 0·23 | 0·41 | 1·4 | 1·40 |
| 77·2 | 16·5 | 2·9 | 1·70 | 0·35 | 0·45 | 2·2 | 1·15 |
| 79·0 | 16·6 | 0·47 | 1·20 | 0·40 | 0·59 | 2·4 | 1·5 |
| 75·9 | 20·7 | 1·0 | 2·9 | 1·28 | 0·9 | 0·4 | 0·3 |
| 77·6 | 19·3 | 0·51 | 1·6 | 0·77 | 0·35 | 1·4 | 1·4 |
| 78·7 | 21·75 | 3·65 | 1·2 | 0·58 | 0·21 | 4·7 | 3·7 |



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# VARIATION IN THE CHEMICAL COMPOSITION OF A FRESHWATER FISH, LABEO FIMBRIATUS

BY

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In migratory marine fishes, variations in chemical composition, especially of fat with season, sexual maturity, etc., have been described (Venkataraman and Chari 1953, Vasavan *et al* 1960, Sohn *et al* 1961) but data on variations in freshwater fishes is not available. A study of the variations of fat, moisture and protein in two cat fishes and a cyprinid (Sreenivasan and Natarajan 1962) showed that the range of variations of these constituents was narrow, and no seasonal pattern could be noted. *Labeo fimbriatus* introduced into the Bhavanisagar Reservoir in 1954 and in subsequent years has grown well and has attained maturity. It is so successful that in commercial experimental fishing, it is caught regularly. Hence, this fish was taken up for study.

### Materials and methods.

The fish caught in the gill nets were never less than 1·5 kg in weight. The procedures described in our earlier publications were followed for analysis.

### Results

The results of proximate analysis of *Labeo fimbriatus* for over a year are presented in Table I. Fish of size ranging from 1,589 g to 5,000 g were analysed. These sizes represent the dominant groups occurring in the experimental nets. In the smaller meshed nets, *Labeo fimbriatus* of smaller sizes were not caught. The "condition factor" was calculated from the formula, $K = \frac{W \times 10^5}{L^3}$. The moisture content of the fish ranged from 72:30 to 84·53 per cent and the fat from 1·05 to 10·81 per cent. The protein also varied greatly—from 10·83 to 21·56 per cent. In figure 1, these three constituents are plotted against months. The vertical lines indicate the fluctuations within that month. For drawing the graph, the mean values were taken.

### Discussion.

Highest fat content in individual fish was noticed in August and next highest in July. The former specimen was a female which was in the earlier stages of maturity (probably after spawning in June) while the other specimen was a milting male. But the fat content did not correlate with stage of maturity in either the female or male fish. It was surprising to find highly mature female in the 5th stage and male (milting) right from April 1961 even till February 1962, which indicates no fixed short period for the maturity of fish. This makes the correlation of maturity with fat difficult. There was also no seasonal variation in the fat content. Explaining the large variations in the fat of mackerel, Sohn *et al* (1961) state that "the mackerel are pelagic fish and the variation in the fat may be influenced by the migratory habits". Venkataraman and Chari (1953) as also Vasavan *et al* (1960) explained that the high fat content of Mackerel and Sardines respectively during particular periods was due to intense feeding on plankton. In freshwater fishes such wide variations of fat are not reported probably because these fishes are just local migratory and they do not have to expend as much energy as anadromous fishes like the salmon which store up high fat. For instance, Thurston *et al* (1959) found only limited variations in the fat of lake herring (0·8 to 4·3 per cent), carp (1·0 to 12·5) and Chub (3·3 to 13·1). The fat content of *Labeo fimbriatus* varies from 1·05 to 10·81 per cent. Fat variation in *L. fimbriatus* is not size-dependent. Three fish of weight 1,816 g. had a fat content each 3·8, 4·5 and 1·63 per cent respectively. No variation based on sex, could be observed either. Similar observations were made with regard to halibut by Thurston and Mc. Master (1960). According to Black (1958), fat storage tissues are primarily the muscles and fat is the principal source of energy. Fat furnishes 9 cal/g whereas proteins and carbohydrates provide only 4·0 cal/g. Thus absence of a stable seasonal variation in fat in *L. fimbriatus* may be due to the fact that there is no need for the expenditure of high amounts of energy. The mean values of fat and moisture correlated inversely in *L. fimbriatus* except for a few months. A more defined inverse correlation existed between fat and protein in this fish throughout the year. In fatty fishes, wide variations in protein were not noted (Venkataraman and Chari 1953, Sohn *et al* 1961). But non-fatty fish like *L. fimbriatus* seem to draw upon muscle protein, which steeply falls beginning from June and touching the lowest level in September. Thereafter it increases, reaching the highest in November and falling off subsequently. During periods of low protein, moisture content was high. This tissue hydration indicates starvation or poor feeding conditions and so it is possible that protein reserves are drawn upon during these periods. *L. fimbriatus* is reported Chacko (1956) to breed during the two monsoons. If so, the protein depletion following June and November could be due to the necessity for the post-spawning build up. Love (1960) considers that muscle hydration is greater in larger fish but this is not true in case of *L. fimbriatus*. Likewise the findings of Fish (1960) that larger *Tilapia* had a higher protein than the smaller ones was not corroborated by the data on *L. fimbriatus* presented here.

Average of one years' data shows that the water content of the male was slightly less (77·1 per cent) than that of the female (77·53 per cent) while the protein content of the male was higher (16·12 per cent) than that of female

(15·4 per cent). The female had lesser fat (4·65 per cent) than the male (5·52 per cent). Idler and Bitners (1958) found that the female salmon used up more protein than the males. The lower average for protein in female *L. fimbriatus* may be due to greater utilization in female.

At particular periods very low concentration of protein occurred in *L. fimbriatus* especially from July to October. It is during this period that floods occur and the food is less available. The high water content of the muscle indicates poor feeding. This low protein has a bearing on the nutritive value of fish. Apart from furnishing very low protein content, such fish have a "sloppy" consistency (Love 1958). For any type of processing, fish at this stage is least suitable. The data on the protein content of *L. fimbriatus* is interesting since such low protein content has not been reported for wild fish in literature.

**Ackowledgments.**

Our thanks are due to Sri V. R. Menon for identifying the stage of maturity of the specimen and to Sri H.K. Ghazi, Director of Fisheries, Madras, for his keen interest in the work and for encouragement.

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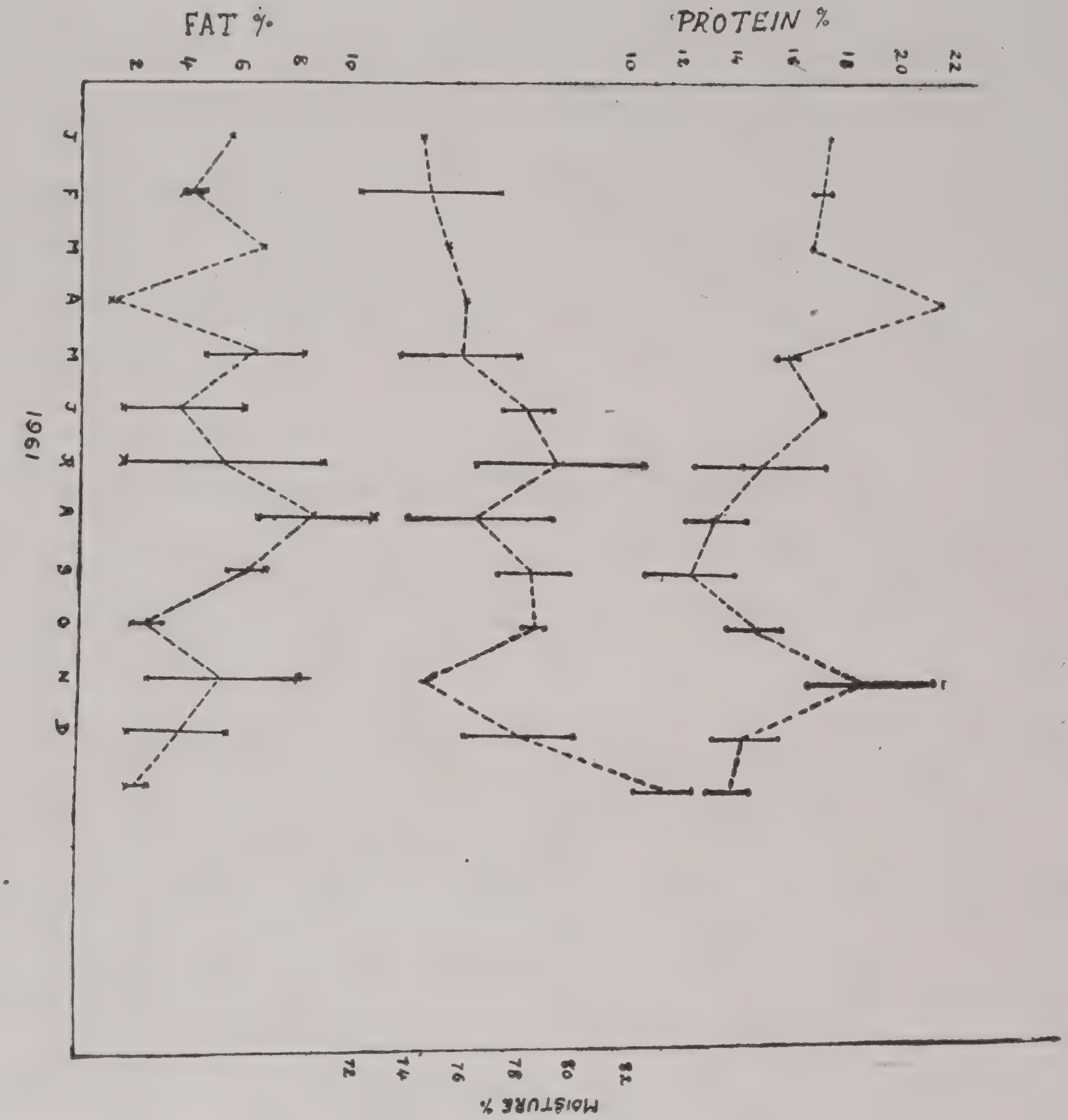
TABLE.

THE VARIATION IN CHEMICAL COMPOSITION OF LABEO FIMBRIATUS.

| *Serial number.* | *Date.* | *Sex maturity.* | *Length.* cms. | *Weight.* G. | *Moisture.* PER CENT. | *Protein.* PER CENT. | *Fat.* PER CENT. | *"Condition factor" K.* |
|---|---|---|---|---|---|---|---|---|
| | | *Labeo Fimbriatus* (Bhavanisagar). | | | | | | |
| 1 | 27th January 1961 | ♂ IV | 73·00 | 4,540 | 74·6 | 17·48 | 5·64 | 1·17 |
| 2 | 2nd February 1961 | ♀ IV | 62·5 | 3,632 | 72·3 | 16·88 | 4·6 | 1·49 |
| 3 | 13th February 1961 | ♂ II | 51·0 | 1,816 | 77·41 | 17·47 | 3·8 | 1·37 |
| 4 | 13th March 1961 | ♀ IV | 47·0 | 1,589 | 75·47 | 16·9 | 6·68 | 1·53 |
| 5 | 11th April 1961 | ♀ III | 52·0 | 2,043 | 76·17 | 21·56 | 1·05 | 1·45 |
| 6 | 4th May 1961 | ♀ V | 66·0 | 4,313 | 73·78 | 16·39 | 8·2 | 1·50 |
| 7 | 19th May 1961 | ♂ V | 51·0 | 1,817 | 78·03 | 15·63 | 4·5 | 1·37 |
| 8 | 1st June 1961 | ♀ V | 50·5 | 2,043 | 79·04 | .. | 1·61 | 1·59 |
| 9 | 14th June 1961 | ♀ V | 57·0 | 2,725 | 79·43 | .. | 4·47 | 1·77 |
| 10 | 21st June 1961 | ♂ V | 56·0 | 2,498 | 77·52 | 17·31 | 6·01 | 1·13 |
| 11 | 5th July 1961 | ♂ V | 68·0 | 4,767 | 76·58 | 14·37 | 8·88 | 1·51 |
| 12 | 7th July 1961 | ♀ V | 53·0 | 1,817 | 79·8 | 17·4 | 1·63 | 1·22 |
| 13 | 21st July 1961 | ♀ II | 57·0 | 2,725 | 82·69 | 12·55 | 3·90 | 1·47 |
| 14 | 8th August 1961 | ♀ I | 56·5 | 2,498 | 74·00 | 14·59 | 10·81 | 1·39 |
| 15 | 17th August 1961 | ♂ forming | 50·00 | 1,817 | 78·37 | 13·31 | 7·13 | 1·45 |
| 16 | 23rd August 1961 | ♀ forming | 54·00 | 2,271 | 79·36 | 12·26 | 6·55 | 1·44 |
| 17 | 13th September 1961 | ♂ spent. | 55·6 | 2,271 | 77·4 | 14·12 | 6·82 | 1·32 |
| 18 | 20th September 1961 | ♀ II | 54·0 | 2,043 | 80·0 | 10·83 | 5·36 | 1·29 |
| 19 | 24th September 1961 | ♀ III | 69·7 | 4,540 | 79·0 | 13·87 | 1·96 | 1·34 |
| 20 | 28th October 1961 | ♀ spent | 68·5 | 3,859 | 78·2 | 15·8 | 3·03 | 1·40 |
| 21 | 15th November 1961 | ♂ .. | 55·8 | 2,300 | 74·8 | 21·36 | 2·54 | 1·32 |
| 22 | 15th November 1961 | ♂ Dev. | 55·6 | 2,000 | 74·82 | 16·79 | 8·13 | 1·16 |
| 23 | 6th December 1961 | ♂ Milty. | 68·5 | 4,500 | 81·5 | 13·35 | 1·79 | 1·40 |
| 24 | 13th December 1961 | ♀ II | 70·5 | 5,000 | 76·19 | 15·70 | 5·45 | 14·27 |
| 25 | 2nd January 1962 | ♀ V | 57·5 | 2,700 | 84·53 | 14·70 | 1·95 | 14·20 |
| 26 | 19th January 1962 | ♂ Milting | 47·1 | 1,500 | 82·43 | 13·21 | 2·612 | 1·435 |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# USE OF CHLORTETRACYCLINE AS A PRESERVATIVE FOR DRY SALTED FISH—I

BY

K. C. JOSEPH, M.SC., RESEARCH ASSISTANT (TECHNOLOGY), FISHERIES TECHNOLOGICAL SUB-STATION, CAPE COMORIN.

## Introduction.

Following the pioneering work by Tarr and his associates (1 to 5) on the use of the tetracycline group of antibiotics in the preservation of fish, much progress has been achieved in retarding the progress of spoilage of fresh, iced and chilled fish by the use of these antibiotics particularly, chlortetracycline commonly known under the trade name aureomycin. The relatively minute concentrations of this substance required to produce effective suppression of spoilage in fish due to bacteria led to great interest in its use by Fisheries technologists all over the world for the preservation of fish and scientific literature is full of reference to work in this field. At present ice containing C.T.C. is widely employed for fish preservation. Similarly, it has been incorporated in chilled sea water, (6) also used for transporting of fresh fish. Velenkar and Kamasastri (7) found that ice containing 5 p.p.m. of C.T.C. enhanced the keeping quality of marine fish packed in it. Visweswariah *et al* (8, 9) found that the keeping qualities of fresh-water fish fillets could be improved by prolonged immersion in C.T.C. solutions and subsequent storage at low temperatures. Sen *et. al.* (10) reported that for salted mackerels a dip in 50 p.p.m. C.T.C. solution before salting appeared to prevent browning of the salted product to a large extent.

Experiments were conducted at the Fisheries Technological Station, Cape Comorin on the use of chlortetracycline as a preservative for four varieties of marine fish cured by the dry salting method. The results of these investigations are presented in this paper.

## Material and Methods.

The experiments were conducted with the fishes, *Lethrinus* Silver bellies, sardines and white bait. The specimens procured for these experiments were all caught in boat seines from the inshore waters off Cape Comorin and were processed immediately after being landed ashore. The specimens were washed clean, first with seawater and then with fresh water and processed as follows :—

### Lethrinus.

The samples were gutted and filletted. The cleaned fillets were then immersed in a solution containing 25 p.p.m. of C.T.C. for five minutes, drained and salted, the salt-fish proportion being 1 : 4 by weight. After 24 hours the salted fish was drained to remove the self-brine and dried in the sun for three days. A control sample was prepared under identical conditions, but for the dip in the antibiotic solution.

### Silver Bellies.

Being small in size, these were not gutted but cleaned by washing only and dipped in 25 p.p.m.C.T.C. solution for one minute. After removing the fish from the dip, the samples were drained and cured with salt under five different salt-fish proportions of 1 : 6, 1 : 7, 1 : 8, 1 : 9 and 1 : 10. The period under cure and the drying time were the same as in the case of *Lethrinus* fillets. Similarly five control samples were also prepared without the C.T.C. dip, other factors being indentical.

### Sardines.

For this fish, a salt-fish proportion of 1 : 7 was adopted and the other particulars were the same as for silver bellies.

### White Bait.

Two different salt–fish proportions of 1 : 4 and 1 : 5 were tried, the other details of processing the same as for silver bellies and sardines.

The cured products were packed in glass jars with screw caps and periodically examined, once a month for a total storage period of six months. Moisture, total volatile basic nitrogen and trimethilamine nitrogen present in the final products were estimated: T.V.B. and T.M.A. were determined by using an extract prepared by grinding the minced fish with 20 per cent trichloracetic acid and employing the microdiffusion method of Conway. The samples were also organoleptically assayed and test scores awarded to each sample, odour, surface moisure and presence or absence of microflora, based on a key for organoleptic assay of dry salted fish worked out by Venkataraman and Vasavan.[19]

## Results and Conclusions.

The results of the periodic analysis are summarised in tables I, II, III and IV respectively for lethrinus, silver bellies, sardines and white bait.

It was found that in the case of *Lethrinus*, silver bellies and sardines, the C.T.C. treated products retained excellent quality for the first three months in storage, whereas the corresponding untreated control samples had retained comparable quality only for the first two months of the period of storage. This was evident from the T.V.B. and T.M.A. values and also on the basis of organoleptic assessment of the samples. In the case of the cured white bait alone, the antibiotically cured products were in excellent condition up to the end of the fifth month in storage and even at the end of six months they were quite good. The degree of spoilage in the C.T.C. treated samples of white bait at the end of the five month storage period was comparable to that in the untreated control samples, at the end of a three month storage period. The enhanced keeping quality of the white bait over the other fishes tried is attributable to the relative superior quality of the starting raw materials and due to certain other chemical factors. In general it was observed that with all the four fishes experimented with and for the different salt : fish proportions tried, the C.T.C. treated products were superior in quality to the corresponding control samples at every stage during the period of storage of six months. The shelf life of dry salted fish could be enhanced by about fifty per cent over that of the ordinary cured products by the application of chlortetracycline before the application of salt for curing of marine fishes, by the method described above.

Considering the great benefits by the adoption of the method of curing described, to the fishing industry especially in India, where the chief method of fish preservation is by salting, the cost of the antibiotic, which is required only in relatively very minute quantities, will be quite negligible and more than compensated for by the improved keeping qualities of the cured products. Further, this will result in the provision of more wholesome protein food for the country's millions whose diet is badly deficient in protein.

Chari[13] found that in *cybium* fillets dipped for one minute in 20 p.p.m. C.T.C. solution and kept in cold storage (3°C) for seven days, the C.T.C. absorbed by the fillets was completely destroyed by heating at 70°C for ten minutes and at higher temparatures for shorter intervals. Thus, under ordinary conditions of cooking the C.T.C. in the antibiotically treated fish is completely removed and hence there cannot be any objection to the use of this preservation for cured fish on the ground that residuary antibiotic in the fish might be injurious to health.

The method of curing fish using aureomycin as a preservative is recommended to the fishing industry for adoption.

Further investigations on the use of C.T.C. as a preservative for the salt curing of other economically important marine food fishes are in progress, the results of which will be published later.

## ACKNOWLEDGMENTS.

I wish to express my thanks to Sri S. T. Chari, Superintendent, Fisheries Technological Station, Tuticorin for his guidance and suggestions during the conduct of these investigations.

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Annexed : Four tables consolidating the data.

**Table I.**—*Data on progress of spoilage in letherinus Fillets cured with salt after treatment with C.T.C. (Salt fish = 1:4).*

| *Number of days in storage.* | *Dried.* | | 30 | | 60 | | 90 | |
|---|---|---|---|---|---|---|---|---|
| *Sample.* | A | B | A | B | A | B | A | B |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Moisture per cent .. .. .. .. | 49·00 | 38·98 | 39·63 | 36·17 | 37·10 | 36·20 | 36·00 | 36·10 |
| T.V.B.N. (mgm./cent) .. .. .. .. | 81·20 | 74·80 | 81·60 | 76·00 | 84·80 | 80·00 | 92·80 | 85·60 |
| T.M.A.N. (mgm./cent.) .. .. .. .. | 70·00 | 60·80 | 68·80 | 64·00 | 72·40 | 68·40 | 72·00 | 68·80 |
| Organoleptic Test Score (max. 30) .. .. | 29·00 | 30·00 | 29·00 | 30·00 | 28·00 | 29·50 | 28·00 | 29·00 |

| *Number of days in storage.* | 120 | | 150 | | 180 | |
|---|---|---|---|---|---|---|
| *Sample.* | A | B | A | B | A | B |
| | (10) | (11) | (12) | (13) | (14) | (15) |
| Moisture per cent .. .. .. .. | 38·42 | 37·24 | 41·52 | 39·39 | 36·90 | 33·72 |
| T.V.B.N. (mgm./Cent.) .. .. .. .. | 123·00 | 97·00 | 173·00 | 128·50 | 204·00 | 172·00 |
| T.M.A.N. (mgm./Cent.) .. .. .. .. | 81·50 | 71·50 | 95·00 | 73·00 | 101·00 | 77·00 |
| Organoleptic Test Score (max. 30) .. .. | 25·00 | 27·00 | 22·00 | 25·00 | 20·00 | 24·00 |

*Remarks*—

A—Control Sample.

B—C.T.C. Treated sample.

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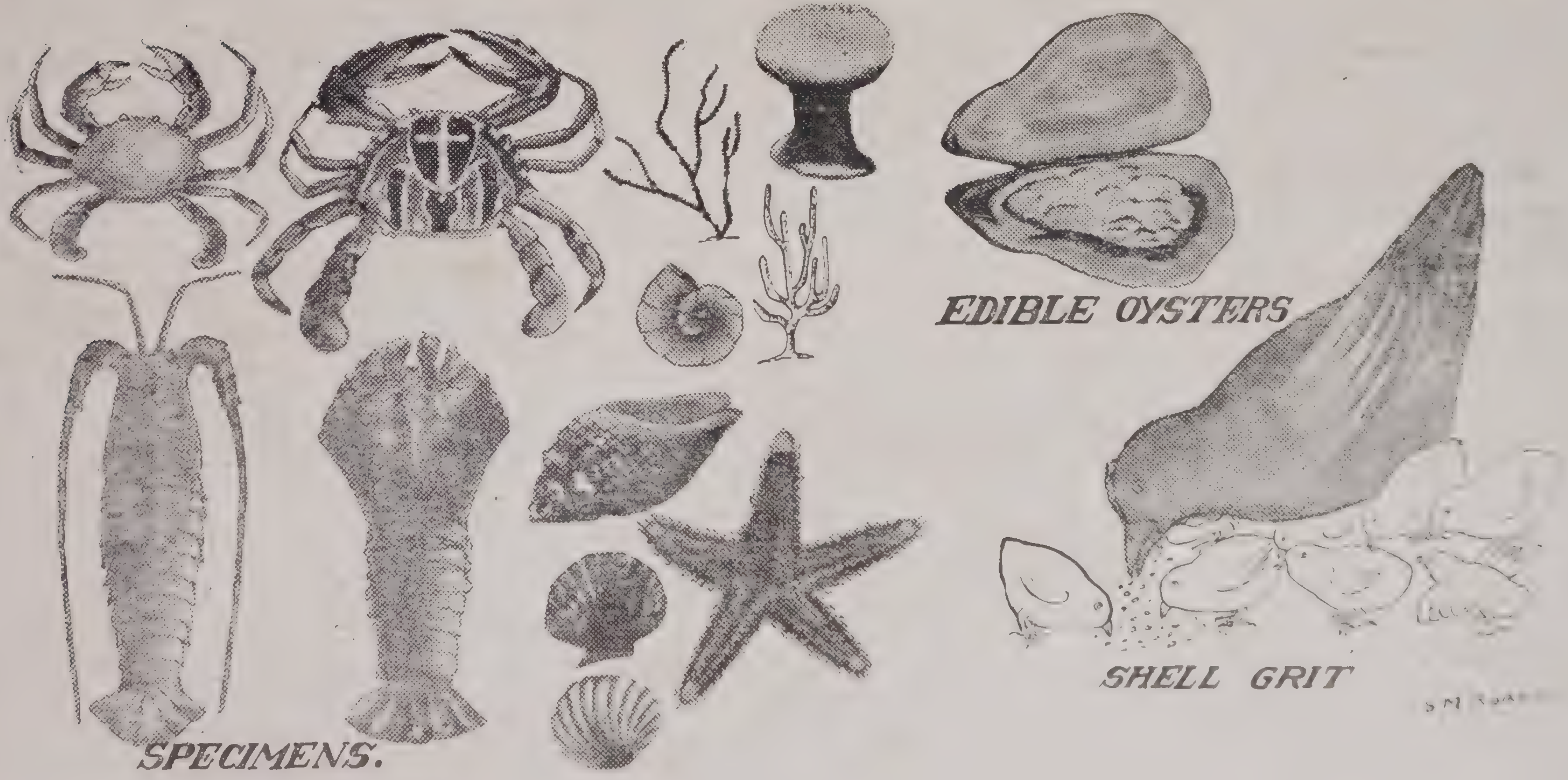

TABLE II—*Data on progress of spoilage in Silver Bellies cured with salt after treatment with C.T.C.*

| *Months after storage.* | *Sample.* | *Control.* | | | | |
|---|---|---|---|---|---|---|
| | *Salt : Fish.* | 1 : 6 | 1 : 7 | 1 : 8 | 1 : 9 | 1 : 10 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Initial | Moisture per cent | 29·20 | 27·96 | 25·42 | 26·60 | 27·4 |
| | TVBN (mgm./cent) | 192·80 | 208·00 | 259·20 | 254·40 | 304·0 |
| | TMAN (mgm./cent) | 78·40 | 79·2 | 81·6 | 88·0 | 137·2 |
| | Org. Score | 28 | 28 | 27 | 27 | 25 |
| First month | Moisture per cent | 29·3 | 28·0 | 25·40 | 26·6 | 27·26 |
| | TVBN (mgm./cent) | 196·0 | 212·8 | 268·8 | 274·4 | 304·0 |
| | TMAN (mgm./cent) | 80·8 | 80·0 | 92·8 | 92·8 | 148·8 |
| | Org. Score | 28 | 27 | 22 | 22 | 20 |
| Second month | Moisture per cent | 34·06 | 30·52 | 29·26 | 32·14 | 30·86 |
| | TVBN mgm. per cent | 224·0 | 222·0 | 300·5 | 312·0 | 356·0 |
| | TMAN mgm. per cent | 85·0 | 91·0 | 121·5 | 127·0 | 163·5 |
| | Org. Score | 26 | 27 | 20 | 19 | 17 |
| Third month | Moisture per cent | 32·24 | 30·08 | 27·72 | 28·33 | 27·18 |
| | TVBN mgm per cent | 262·0 | 260·0 | 368·0 | 396·0 | 421·0 |
| | TMAN mgm. per cent | 96·0 | 94·0 | 158·0 | 161·0 | 188·0 |
| | Org. Score | 23 | 24 | 17 | 18 | 13 |
| Fourth month | Moisture per cent | 35·87 | 35·99 | 32·00 | 29·14 | 35·67 |
| | TVBN mgm. per cent | 318·0 | 310·0 | 380·0 | 411·0 | 425·0 |
| | TMAN mgm. per cent | 114·0 | 116·0 | 168·0 | 164·0 | 197·0 |
| | Org. Score | 18 | 19 | 14 | 14 | 11 |
| Fifth month | Moisture per cent | 35·64 | 36·29 | 31·13 | 28·90 | 35·26 |
| | TVBN mgm. per cent | 335·0 | 316·0 | 380·0 | 410·0 | 425·0 |
| | TMAN mgm. per cent | 115·0 | 116·5 | 169·0 | 166·0 | 196·5 |
| | Org. Score | 17 | 19 | 13 | 14 | 10 |
| Sixth month | Moisture per cent | 36·10 | 36·41 | 31·80 | 30·20 | 34·82 |
| | TVBN mgm. per cent | 372·0 | 360·0 | 394·0 | 450·0 | 448·0 |
| | TMAN mgm. per cent | 121·0 | 124·0 | 178·0 | 197·0 | 201·0 |
| | Org. Score | 16 | 17 | 13 | 13 | 9 |

TABLE III—*Data on progress of spoilage in Sardines cured with salt after treatment with CTC (Salt : Fish—1 : 7 by weight.)*

| *Storage period.* | *Initial.* | | *30 days.* | | *60 days.* | |
|---|---|---|---|---|---|---|
| *Sample.* | A | B | A | B | A | B |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Moisture per cent | 42·61 | 41·88 | 40·84 | 41·60 | 40·18 | 41·40 |
| TVBN (mgm./cent) | 212·5 | 171·5 | 267·5 | 210·0 | 320·0 | 225·5 |
| TMAN (mgm./cent) | 149·5 | 78·5 | 175·0 | 91·5 | 146·5 | 105·2 |
| Org. Score (Max. 30) | 28 | 29 | 28 | 29 | 25 | 28 |

| *Storage period.* | *90 days.* | | *150 days.* | | *180 days.* | | *Remarks.* |
|---|---|---|---|---|---|---|---|
| *Sample.* | A | B | A | B | A | B | |
| | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| Moisture per cent | 40·00 | 41·41 | 40·60 | 41·08 | 40·08 | 41·16 | |
| TVBN (mgm./cent.) | 322·0 | 222·0 | 384·0 | 242·0 | 412·0 | 248·0 | |
| TMAN (mgm./cent.) | 136·0 | 107·0 | 184·0 | 114·0 | 180·5 | 120·0 | |
| Org. Score (Max. 30) | 20 | 25 | 17 | 24 | 13 | 22 | |

A—Control sample.
B—CTC Treated sample.

TABLE II—*Data on progress of spoilage in Silver Bellies cured with salt after treatment with C.T.C.*—cont.

| *Months after storage.* | *Samples.* *Salt : Fish.* | *C,T,C, Treated.* | | | | |
|---|---|---|---|---|---|---|
| | | 1 : 6 (8) | 1 : 7 (9) | 1 : 8 (10) | 1 : 9 (11) | 1 : 10 (12) |
| Initial | Moisture per cent | 30·31 | 29·49 | 29·26 | 26·97 | 25·99 |
| | TVBN (mgm./cent) | 110·4 | 114·0 | 141·2 | 211·2 | 211·2 |
| | TMAN (mgm,/cent) | 47·6 | 67·2 | 78·4 | 91·2 | 104·8 |
| | Org; Score | 30 | 30 | 29 | 28 | 27 |
| First month | Moisture per cent | 30·24 | 29·5 | 29·25 | 27·0 | 26·14 |
| | TVBN (mgm,/cent) | 111·2 | 114·8 | 114·0 | 212·8 | 217·6 |
| | TMAN (mgm,/cent) | 47·6 | 68·8 | 77·6 | 121·6 | 130·0 |
| | Org, Score | 30 | 30 | 29 | 25 | 25 |
| Second month | Moisture per cent | 34·03 | 32·34 | 31·30 | 31·36 | 33·98 |
| | TVBN mgm, per cent | 125·0 | 128·0 | 161·0 | 240·5 | 246·0 |
| | TMAN mgm, per cent | 77·5 | 72·5 | 89·0 | 126·0 | 128·0 |
| | Org, Score | 30 | 30 | 28 | 25 | 24 |
| Third month | Moisture per cent | 32·16 | 31·10 | 30·25 | 31·06 | 29·65 |
| | TVBN mgm, per cent | 146·5 | 150·5 | 174·0 | 286·0 | 300·5 |
| | TMAN mgm, per cent | 84·25 | 105·0 | 97·0 | 151·0 | 155·5 |
| | Org, Score | 25 | 25 | 24 | 22 | 19 |
| Fourth month | Moisture per cent | 37·47 | 31·82 | 35·22 | 33·14 | 36·46 |
| | TVBN mgm, per cent | 184·0 | 180·0 | 183·0 | 288·0 | 324·0 |
| | TMAN mgm, per cent | 92·0 | 104·0 | 101·0 | 153·0 | 162·0 |
| | Org, Score | 23 | 23 | 21 | 19 | 18 |
| Fifth month | Mositure per cent | 36·17 | 31·86 | 35·24 | 33·35 | 36·29 |
| | TVBN mgm, per cent | 184·0 | 182·0 | 184·0 | 289·0 | 332·0 |
| | TMAN mgm, per cent | 91·0 | 104·0 | 101·0 | 167·0 | 166·0 |
| | Org, Score | 22 | 22 | 19 | 17 | 16 |
| **Sixth month** | Moisture per cent | 35·18 | 31·88 | 35·60 | 34·64 | 36·54 |
| | TVBN mgm, per cent | 198·0 | 208·0 | 206·0 | 284·0 | 342·0 |
| | TMAN mgm, per cent | 90·0 | 106·0 | 104·0 | 170·5 | 176·0 |
| | **Org, Score** | **22** | 22 | 18 | 16 | **14** |

TABLE IV—*Data on storage studies on CTC Treated Fish—White-Bait,*

| *Salt Fish,* | *Period of storage (days,)* | *Control sample.* | | | | *CTC Treated sample.* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Moisture.* | *TVBN* | *TMAN* | *ORG score,* | *Moisture.* | *TVBN* | *TMAN* | *Org. score.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1 : 4 | 60 | 30·48 | 134·0 | 60·5 | 28·0 | 31·20 | 108·0 | 48·0 | 29·0 |
| | 90 | 30·62 | 144·2 | 61·2 | 27·0 | 31·06 | 112·75 | 52·0 | 28·0 |
| | 120 | 30·80 | 153·0 | 63·0 | 26·0 | 31·08 | 120·0 | 55·5 | 28·0 |
| | 150 | 30·14 | 164·0 | 64·75 | 24·0 | 31·61 | 127·5 | 58·0 | 27·0 |
| | 180 | 30·68 | 186·0 | 70·0 | 21·0 | 32·40 | 147·5 | 63·0 | 24·0 |
| 1 : 5 | 60 | 31·12 | 138·0 | 61·5 | 27·0 | 31·30 | 110·25 | 50·25 | 29·0 |
| | 90 | 32·00 | 148·6 | 63·8 | 27·0 | 31·42 | 116·0 | 51·6 | 28·0 |
| | 120 | 31·60 | 155·5 | 64·0 | 26·0 | 30·60 | 121·0 | 54·0 | 28·0 |
| | 150 | 32·08 | 165·0 | 67·5 | 24·0 | 31·26 | 126·0 | 57·5 | 27·0 |
| | 180 | 32·42 | 185·0 | 72·0 | 21·0 | 33·08 | 144·0 | 64·0 | 24·0 |

Remarks,—(1) Moisture as per cent.
(2) TVBN and TMAN as/mgm,/cent.
(3) Org. Score out of a maximum of 30.

# USE OF TURMERIC AS A PRESERVATIVE FOR DRY SALTED WHITE-BAIT FISH.

BY

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## I. Introduction.

Salting is by far the most important and extensively employed existing method for the preservation of fish in India. But owing to various factors such as non-availability of good quality salt, defective and inadequate curing methods and lack of proper storage facilities, the cured fish seldom keeps in good quality by the time it reaches the consumer. More often than not, the cured fish sold in our interior markets is in too advanced a stage of putrefaction to be fit for human consumption. Observations on commercially cured fish from fish-curing yards and fish markets in Malabar and South Canara Districts (Venkataraman and Vasavan—1955) as well as similar studies conducted by others on commercially cured fish in India revealed that the condition of the products was far from satisfactory, (Nicholson, 1905 Venkataraman 1951, Velankar, 1952; Venkataraman *et al*, 1954). The use of salt of greater purity and addition of various chemical preservatives have been suggested by various workers in the field in order to improve the quality of cured fishery products. Because of practical difficulties in adopting these methods' it was thought worthwhile to try the use of some simple indigenous preservative that could be mixed with the salt used for curing of fish. It was in this connection that investigations were taken up on the effect of turmeric added to salt used for curing of fishes. Turmeric is an essential condiment used in the preparation of a large number of dishes of the Indian menu. It is a common practice for the housewife to add, a little bit of ground (fresh or dried) turmeric along with salt when fresh-water fishes caught in excess of daily requirements from the rivers are to be preserved for the next day or two for consumption. The results of investigations carried out by the author on the effect of addition of varying percentages of turmeric powder to salt used for curing the marine fish, white-bait (*Anchoviella heteroloba, A. Zollingeri and A. Commersonii*) are presented in this paper. This particular fish was chosen as it contributes to an economically important fishery in this region and the existing method of preservation of this fish by mere sun drying as practised by the local fisher-folk is far from satisfactory. It was also observed that when merely salted and dried white-bait was kept in storage it started crumbling to pieces in about two months' time unlike other fishes having relatively more of fibrous tissue than this fish.

## II. Materials and methods.

Venkataraman and Vasavan (1955) showed that a salt to fish ratio of 1 : 5 or 1 : 6 was adequate to ensure good keeping quality for dry salted white-bait from the west coast. For the present study a salt to fish ratio of 1 : 5 by weight was chosen. Freshly landed fish was purchased for these experiments from the catches of boat seines landed at Cape Comorin. The fish was cleaned well by washing and was cured under controlled conditions with crushed salt mixed with commercial turmeric powder, available in the market packed in paper cartons and sold for domestic use, so that the percentage of turmeric in the salt-turmeric mixture used for curing the fish varied from 0 to 15 by weight. The period under cure was 24 hours and the period of drying (By Solar heat) was 12 hours. The salt used was the same as issued from the local fish curing yards for curing fish. The cured products were stored in deal wood boxes lined with paper and samples were examined organoleptically and chemically after storage for 15, 30, 45, 60, 90 and 120 days, by taking representative samples from each lot.

Moisture was determined according to A.O., A.C. method of analysis on the entire finely ground fish. Estimation of total volatile basic nitrogen was carried out with the whole ground fish according to Okoloff's magnesium oxide distillation method as adopted by Lucke and Ceidel (1932) and recommended by Winton and Winton (1947). Organoleptic evaluation of the samples was conducted by noting the appearance, texture, flavour, odour, surface moisture and presence or absence of mould growth. The key for organoleptic assay of salted fish based a numerical scoring system worked out by Venkataraman and Vasavan (1955) for west coast fishes was adopted for these experiments with slight modifications.

## III. Results and discussions.

Six samples of white-bait were cured with salt and turmeric, the percentage of the turmeric in the mixture being 2, 3, 4, 5, 10 and 15. A control sample was cured with salt alone. The results of the experiments are given in Table I. The variation of total volatile basic nitrogen in the samples on storage for 120 days is graphically represented in Figure I where curve A shows the change in T.V.B.N. values for the control sample. In the samples cured with mixtures of salt and turmeric the levels of T.V.B. Nitrogen were much less than in the control sample and these were proportionately less with the increase in the percentage of turmeric added but for slight deviations towards the fag end of the storage period. This is evident from the curves, B, C, D, E and F in figure I. These findings will be further verified from figure II where the T.V.B.N. values at the various intervals have been plotted against the percentage of the condiment in the salt turmeric mixtures used. These prove that the presence of turmeric along with the salt used for curing white-bait enhanced the keeping quality of the cured products. It was seen that with increasing percentages of turmeric the final products contained relatively less amounts of total volatile basic nitrogen at different intervals during storage. In other words spoilage had not taken place to the same extent in products obtained with salt-turmeric mixtures as in those treated with salt alone; and the extent of spoilage was, in general progressively smaller with increasing quantities of turmeric added. But taking into consideration the general appearance of the product from the point of view of marketability and consumer appeal, it was found that more than 5 per cent of turmeric was not advisable as with a higher percentage the characteristic colour, odour and flavour due to excess of turmeric became very evident masking the fishy odour and flavour.

## IV. Conclusions.

The incorporation of about 5 per cent by weight of turmeric mixed with salt used for curing white bait results in a better product with enhanced keeping quality than products obtained by processing with salt alone. The preservative action of turmeric appears to be due to some bacterio-static principle present in it and responsible for inhibiting the growth of fish spoilage bacteria.

The method of curing described is recommended for adoption by the fishing trade for salting white bait to obtain a better product of superior keeping quality for human consumption and to prevent the huge wastage of this valuable protein food resulting from the inadequate methods of preservations now employed.

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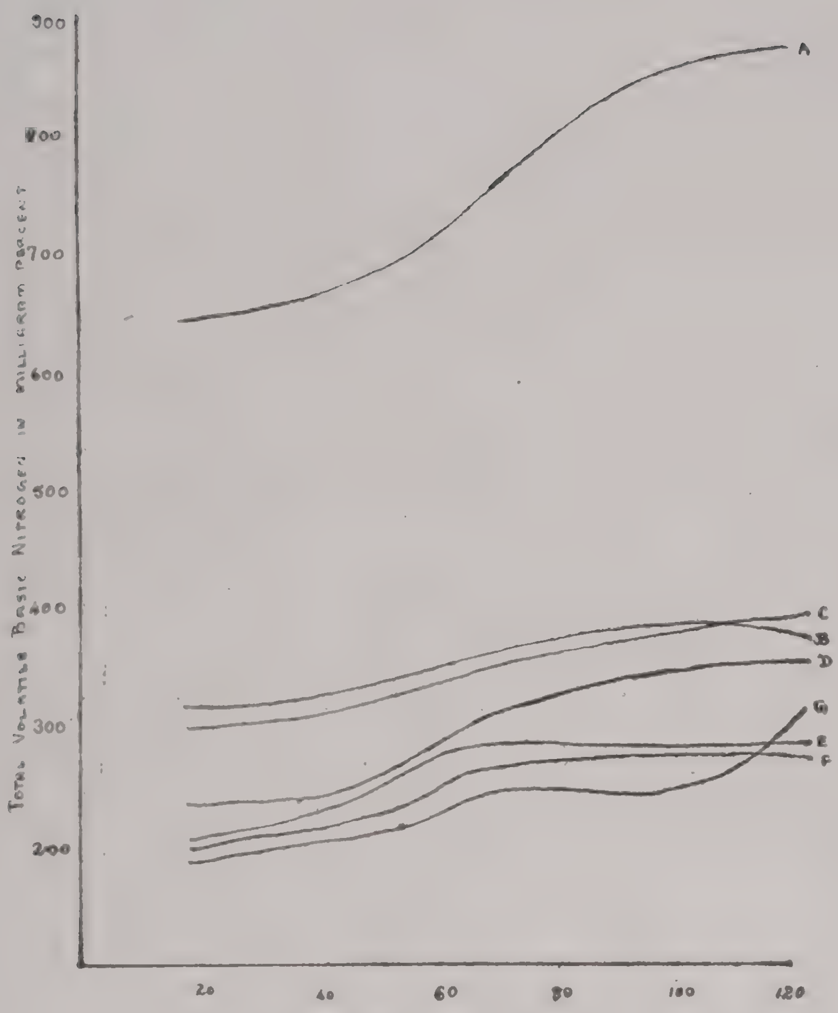
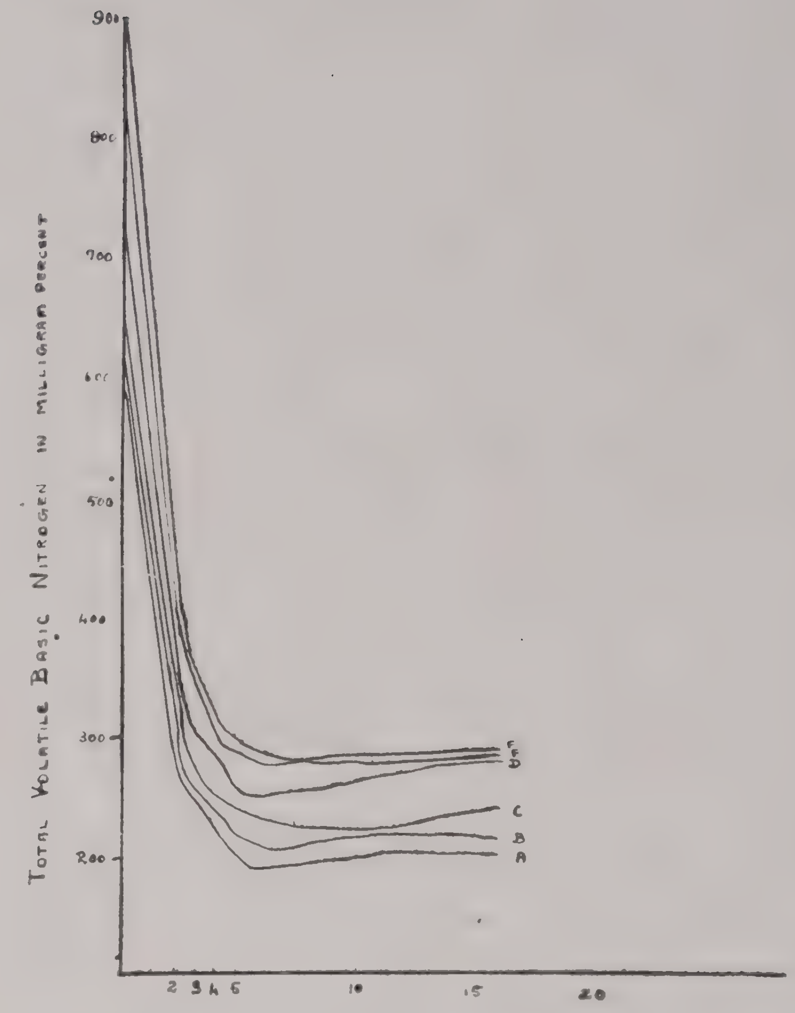
VISIT
FISHING HARBOUR AT
CUDDALORE.



Storage period in days.

FIG. I—Graph showing effect of different quantities of turmeric added to salt used for curing White-Bait on total volatile basic Nitrogen content of cured products during storage for 120 days. A—control sample cured with salt alone; B. C. D. E. & F.—Samples cured with Salt—Turmeric mixtures containing 2% ; 3% ; 4% ; 5% ; 10% and 15% respectively of turmeric powder.



% By Weight Turmeric in Salt—Turmeric Mixture.

FIG. II—Graph showing variation of T. V. B. N. with percentage of Turmeric added to salt used for curing White-Bait for storage periods of 15 days (cure—A), 30 days—(B), 45 days (C), 60 days (D), 90 days (E) and 120 days (F).

# CATCH—EFFORT OF INDIGENOUS FISHING CANOE IN THE PALK BAY

BY

P. I. CHACKO.

The Palk Bay is the shallow sea between India and Ceylon, north of the Pamban Pass. The average depth is about 5 fathoms. The bottom is muddy. The common fishing canoe of this region is of a distinct type of the outrigger class. The outrigger consists of a long and heavy plank laid athwart so that each end projects outboard a considerable size on either side. By loading the projecting section on weather side with one or two members of the crew a very efficient counterpois is obtained. The canoe is about 35 feet in length and 5 feet broad and 3 feet deep. A main mast is employed for propulsion and less frequently a mizzen in addition. The characteristic feature is the presence of a pair of quarter steering-boards instead of a fixed rudder.

The catch-effort efficiency of such a typical fishing boat was studied with Adirampatnam as base, for one year from April 1959 to March 1960. A crew of five and a set of 15 gill-nets were employed. The quantity of fish captured and the sale-proceeds during the twelve months were as shown below :—

| *Month.* | *Number of fishing days.* | *Quantity of fish caught.* | *Sale-proceeds.* | |
|---|---|---|---|---|
| | | LB. | RS. | NP. |
| April .. .. .. | 25 | 4,538 | 698 | 90 |
| May .. .. | 26 | 3,197 | 477 | 71 |
| June .. .. | 26 | 2,605 | 358 | 84 |
| July .. .. .. | 24 | 2,488 | 244 | 29 |
| August .. .. | 26 | 3,989 | 452 | 57 |
| September .. .. | 22 | 3,330 | 414 | 85 |
| October .. .. | 11 | 4,456 | 681 | 80 |
| November .. .. | 5 | 214 | 39 | 18 |
| December .. .. | 22 | 1,096 | 173 | 35 |
| January .. .. | 14 | 1,018 | 148 | 54 |
| February .. .. | 19 | 2,036 | 306 | 04 |
| March .. .. | 24 | 2,826 | 439 | 74 |
| Total .. | 244 | 31,793 | 4,435 | 00 |

The catches were good from January to August when south and south-west winds prevailed. With the onset of the north-west winds, the catches improved in the months of September and October. But when rain and cyclonic conditions prevailed from November to January, fishing was not favourable. The conditions improved in February and March. The catches consisted of skates, rays, saw fishes, cat fishes, leather-jackets, jew fishes hilsa and others.

The catch-effort of the canoe and the crew, quantitatively and qualitatively are given below :

| *Month.* | *Catch per day.* | *Sale proceeds per day.* | | *Catch per day per fisherman.* | *Income per day per fisherman.* | |
|---|---|---|---|---|---|---|
| | LB. | RS. | NP. | LB. | RS. | NP. |
| April .. .. | 181·72 | 27 | 92 | 36·34 | 5 | 58 |
| May .. .. | 123·00 | 18 | 37 | 24·74 | 3 | 67 |
| June .. .. .. | 100·18 | 13 | 80 | 20·04 | 2 | 76 |
| July .. .. | 103·66 | 10 | 18 | 20·73 | 2 | 03 |
| August .. .. | 153·42 | 17 | 40 | 30·68 | 3 | 68 |
| September .. .. | 151·36 | 18 | 85 | 30·27 | 3 | 77 |
| October .. .. | 405·09 | 61 | 98 | 81·02 | 12 | 39 |
| November .. .. | 43·80 | 7 | 83 | 8·76 | 1 | 66 |
| December .. .. | 49·81 | 7 | 88 | 9·96 | 1 | 57 |
| January .. .. | 72·72 | 10 | 62 | 14·54 | 2 | 12 |
| February .. .. | 107·15 | 16 | 14 | 21·43 | 3 | 23 |
| March .. .. | 117·74 | 18 | 32 | 23·25 | 3 | 66 |
| Average for the year | 130·29 | 18 | 17 | 26·06 | 3 | 65 |

The average catch per day of fishing by the canoe varied from 43·80 lb. in November to 405·09 lb. in October. Excepting the cyclonic months of November, December and January the catch per day exceeded 100 lb. The sale proceeds per day varied correspondingly from Rs. 7·83 in November to Rs. 61·98 in October. The catch and income per fishermen per day varied from 8·76 lb. and Rs. 1·56 to 81·02 lb- and Rs. 12·39. The average per day for the whole year was 26·06 lb. and Rs. 3·65 per fisherman.

This study has helped to work out the economics of fishing operations by indigenous craft and gear.

# FISHING METHODS OF SCOMBROIDS IN MADRAS COAST

BY

SRI DAVIDSON THOMAS, SUPERINTENDENT, INSHORE FISHING STATION, RAMESWARAM.

The fishes of the Scombroid group form an important fishery in the Madras Coast esteemed as economically important. Seer is to-day the most priced fish valued as a class table variety. Tunas have potential value though are landed in lesser quantities now, compared to Seer. But this gives ample promise to improve the landings in the future. Mackerel is yet another group which forms an important fishery in certain selected centres during the season. But along the East coast the fish is not caught in such large quantities as in the West Coast. The Bill fishes, predominantly a deep water variety are rarely caught in Trolling lines. This fish is not considered as economically important in Madras State.

The Madras Coast could be broadly classified into—

(1) the Coromandel Coast which extends from Madras south-ward up to Point Calimere. The coast line is mostly surf beaten and has steep gradient in the depth. Catamarans are the common craft used; large masula boats are also operated for shore seines in some places;

(2) The Palk Bay Coast commencing from Point Calimere extends up to Dhanushkodi. The Bay is mostly of even depth with a maximum depth of 9 fathoms. The depth gradient is very gradual like a shallow plate. The sea bed is mostly of soft mud except for the coral beds off Rameswaram up to 6½ fathoms;

Mookur type vallams and round bottomed Carvel built shallow boats of Thondi type are the common crafts;

(3) the Gulf of Mannar extends from Dhanuskodi towards west and south up to Kanyakumari. The sea coast is rugged and is surf beaten along the beach south of Tuticorin. The various pars and coral reefs in this sea afford good possibilities for fishing on rocky bottom. Canoes are used up to Tuticorin and 3 logged boat catamaran are operated in the rugged southern coast line; and

(4) the Kanyakumari Coast extends into the Indian Ocean which has a steep gradient of depth extent for a few sheltered bays. The coast line is mostly surf beaten and is reputed for the reefs near the shore line.

Catamaran is the common craft used in this coast.

## Seer

Seer is a well known Scombroid and is largely caught in the Gulf of Mannar and Palk Bay. Of the two common varieties known, *C. Guttatum* and *C. Commersoni*; the former is more commonly available and is landed in large quantities. *S. eneslatus* is also found in the catches specially in the Palk Bay region.

Being a variety more commonly found along the surface and upper column the most effective gear, used commonly to land this fish is the 'Drift Net' operated mostly from the Tuticorin and Mookur type canoe. The average size range landed in Drift nets is 2–9 lbs. Large-sized seer weighing above 10 lb up to about 50 lb are landed mostly in 'Trolling lines'.

The 'Drift Net' is a set of Gill nets usually 20 fathoms long and 6½–7 fathoms deep. The mesh size range from 3″–4½″. In recent times the net is constructed with Synthetic fibre of breaking strength 35—40 lb. (commonly) and Dunlop twine of which this gear was made of even three years back has become almost obsolete.

To the upper edge is fixed one mesh selvage of thick material which is about two times the mesh size and carries usually 3 meshes in it, left loose.

The head rope, usually of 4 Ply 3/4″ thick hard twisted coir is passed through the thick selvage mesh and the meshes are made fast at intervals of 1–1½ fathoms leaving 14 or 16 selvage meshes in between, to give 40 per cent—50 per cent framing. Usually the nets are framed a little stretched in the Palk Bay compared to the Gulf of Manar nets.

No ground rope is used. 15–18 such nets form a 'Set'. Wooden floats of light timber about 3″×9″ are used as floats fixed on snoods of about 1 foot at intervals of 1–1½ fathoms. Small stone sinkers are fixed at intervals of 4–6 fathoms joined to the lower edge of the net, and the number of sinkers varies according to the force of current and depth operated.

The canoes sail out in the evening and set their gear at dusk. From the set, lead a long thick net warp of about 30 fathoms by which the canoe is attached to the set and drift. The net is hauled up once after mid-night and re-laid. At day break the set is hauled in and the canoes return ashore with the catch. Seer and Sabre fish are the usual catch for this gear though *Caranx*, *Chorinemus*, Sharks, etc., are also landed. In the Gulf of Mannar, Seer is caught in large number between September and January. This fish is landed in considerable quantities in the Palk Bay with this gear from March–August. The Seer caught with the Drift net are usually small sized weighing up to 10 lb. and mostly belong to C. guttatum and *Scomber lanceolatus*.

In the Gulf of Mannar the large sized Seer usually *C. commersoni* are landed in Trolling line. Seer of 10–50 lb. is common for this gear mostly during September and October.

In the Coromandel coast Seer are not landed in large quantities as compared to the Gulf of Mannar and Palk Bay. The Drift net is not much developed in this zone. Those used are only 10-12 fathoms long and are about 3-4 fathoms deep. Ten such nets are usually operated from a catamaran.

Here again, the large-sized Seer, is caught in the trolling line operated from the catamaran while returning from other types of fishing in September–November. Thus it would be observed that the Seer Fishery is not very important in this area compared to the Palk Strait or the Gulf where this gear for Seer is more effective and widely used.

In the Kanyakumari Coast Seer is caught in smaller quantities by the Drift nets which again is about 4½ fathoms deep. 10-12 nets of 12 fathoms are operated from the catamaran. But often good quantities of *C. guttatum* are landed in the Shore seine from August to September in the Northern Coast of the district.

Seer, as already stated is commercially the most important Scombroid. This is greatly priced as a table fish. Cured Seer (Keelam) is valued in Ceylon and mostly 'Tub cured'. Pit cured Seer is sold in inland markets only.

Seer is popularly called "Seela", "Naimeen", "Vanjiram", "Mavilasi" and "Arikula" in different places along the coast line.

The fish gets easily tainted and it is very difficult to land all the catch in fresh condition.

**Mackerel.**

The second important fishery of the group known commonly is the Mackerel (*Rastrelliger Canagurta*). This is popularly called in the local language as "Iyla", "Kanankeluthi" or "Kumbla." Mackerel is a pelagic fish mostly found in shoals and migrates closer to shore during the seasons.

Along the Kanyakumari Coast in places like Thengapattinam, Thoothur, etc., Mackerel are landed in fairly good quantities in shore seine net during August–October when the south-west monsoon had dwindled down. Further north in the Gulf of Mannar along the Idinthakarai Coast mackerels are landed in the bag nets between November–January fairly close to the coast in 7–12 fathoms. Very often mackerels are landed in smaller numbers in the drift nets of 3″ mesh along with seer and sabre fish off Tuticorin and Manapad. Tracing north-east, from Tuticorin along the coast, mackerel is landed in good numbers in the shore seine operations at Valinookam and in the Gulf islands during October–December.

Mackerel is landed more predominantly at the Dhanushkodi coast from November–February where large quantities are sometimes caught. fifteen to twenty thousand Mackerel have been landed in Shore seine at Dhanushkodi during these months. The most effective or common gear by which mackerel is landed in large quantities is the Kara Valai in the Gulf of Mannar, Coromandel Coast and in the Kanyakumari district.

The *Kara Valai* meaning "Shore net" of the Palk Bay and Gulf of Mannar are identical in design though the one operated in the Gulf is provided with a bigger bag and higher wings (Marukku).

The 'Karavalai' consists of a cod end of thick cotton (20×15) of ½″ mesh 4 fathoms in circumference. The whole bag is 7 fathoms deep from the mouth to the bunt. Next to this bag on either side are laced the wing pieces which are also of cotton 9 fathoms high and 15 fathoms long made of ½″ mesh.

Next to this cotton wing piece on either side are joined 6 portions of coir wings, the mesh size of which increase progressively from 6″ to 90″ from the centre towards the free end which is 215 fathoms long. To this is attached the warps, coils of coir rope of each 60 fathoms long and 1″ thick.

In the operation the whole net is loaded in a boat and the end of one of the warps is left in the shore and the boat carrying the net move away from the shore forming an arch, and as the boat moves the net is paid out in such a way that the bag comes in the centre of the thus enveloped area and the other end warp is brought to the shore away from the first warp end.

The distance up to which the net is expected to operate depends on the number of warp coils used in the operation. The shore seines are normally operated up to about one mile from the beach and fishes that are enveloped inside the arch formed while setting the net are hauled up and collected in the bag.

In the Palk Bay, a few Mackerels are landed in the Drift nets along with other fish occassionally and not occur as a regular fishery in good quantities.

Along the Coromandel Coast Mackerels are landed in large numbers north of Nagapattinam. The appearance of Mackerels along this coast is between February–May. During this time mackerels are landed in fairly good quantities in the Drift net used specially in the nets of 3″ mesh size and less. Along the Pondicherry and Cuddalore Coast Mackerels are also landed in the "Edavalai" during April and May, when a maximum of 500–600 numbers are landed in a single operation.

North of Pondichery, in the Madras Coast Mackerel is mostly landed in the "Shore Seine" net "Periya valai". This is the most effective gear along this coast when 5,000–6,000 numbers are landed in a single operation during April and May when the north-east monsoon is subdued. The "Periya valai" used in the Coromandel Coast is similar to the Shore seine already described except for the bag which is tapered into a cylinderical bag.

Along Pondichery, Marakanam coast, Mackerel is also landed occasionally during the months of August–September in "Edavalai" and in the shore seine 'the Periya valai'.

Mackerel also occupies a place of economic importance in the fishery of East Coast, though it is not so marked as in the West Coast of India.

As a Table fish, Mackerel occupies a place of lesser importance compared to the Seer. But cured Mackerel is well in demand specially among the working classes of inland districts and the up-country estate labour.

Tunas form yet another large group among the scombroids, though not so commonly known as the Seer or Mackerel being mostly a deep water variety.

Three varieties of Tunas are known in the fishery of Madras Coast :—

| | |
|---|---|
| (1) *Euthynnus affinis* .. .. | " Soorai " (Tamil) |
| (2) *Kishinoella tonggol* .. | " Kilavalai "(Tamil) |
| (3) *Neothunnus Macropterus* .. | " Ettallai " (Tamil) |

Of the three twine Tunas *Euthynnus sp.* is more commonly known to the fishermen than the other two varieties mainly because of their occurrence shore ward.

" Soorai " (Tamil) *Euthynnus affinis*, the smaller number of the group and most commonly landed of all the Tuna members. On the average *E. affinis* weighs 8–15 lb.

In the Kanyakumari Coast this also occurs in the Bottom Set nets of Nylon mostly in 6″ nets in 15–20 fathoms depth. On certain occasions during August and September about 1,500 lb. have been landed in a set. In the Coast of Thengapattinam, Enayam, Puthenthurai, Thoothur, etc., this is caught in shore seine net called " Peru valai ".

Tracing north in the Gulf of Mannar *E. affinis* are landed in the ' Pachu valai ', local set net, off Idinthakarai Manapad, etc., in 15–20 fathoms during August to October. These nets are made of thick hemp and are of 5–6 ″ mesh size. However, these have been now replaced by nylon material.

Off Tuticorin and Sippikulam, Kilakarai, etc., " Soorai " is caught in the Drift net as well as in the Trolling line, which is like a game fishing tackle. Mostly big Seer and the bigger members of the Tuna group are landed in the Gulf of Mannar in trolling lines only.

The fishermen in the Gulf of Mannar specially those of Tharuvaikulam who are specialists in trolling line fishing use Carvel built sailing boats of 32–34 feet which have good sailing speed. Special hard twisted lines of about 4 m.m. thick and 30 fathom long are used as the line. No. 1 hooks are used mostly, attached to the line by a shining German Silver and Copper wire snood of about 1 fathom length. The hook is usually hid by a tuft of lure fibre tied at the stalk of the hook to which the full bait, Sardine or Mackerel is hooked and tied to resemble a live fish on the move.

In the Kilakarai area, specially made flattered hooks with longer stalks are used instead of the standard mustered hooks as the fishermen believes that the special hooks have better catching power and help to keep the bait straight.

A typical trolling canoe is a Tuticorin type boat about 32 feet long. It carries mostly a single mast and a lug sail. Provision is also made in the boat for a second aft mast to carry an additional sail if required. The canoe usually carries heavy ballast of sand bags to counteract the litting by the sail.

The bamboo poles are carried on either side of the canoe to which the trolling lines are attached. Usually 4 lines are carried on each bamboo or either side of the canoe. From the sail yard is drawn a line to the stern and to this is attached a line. Thus on an average 9 lines are carried in a " troller canoe ". The canoes set sail to the ground in the morning and reach the fishing ground usually about 16–20 fathoms and look out for indication of schools of big fish viz., Tuna, *Caranx*, Seer or *Chorinemus* and set the baited line and set sail in the favourable direction.

When the lines start fishing the crew in charge of the line haul up the line with maximum speed and reset. The canoes usually change the course and run in such a way that the lines are dragged in an area where the catch occurs and the speed of the canoe is usually kept uniform adjusted to the speed in which the first fish was caught that day.

Off Kilakarai, the Trolling boats are the typical Keelakarai or Thondi type with round bottom, narrow beam with balance beam and raised bow. The popularly called " Kulla Dhoni " are the out-rigger canoes operating off Kilakarai which specialise in trolling lines.

The trolling line fishermen have given typical names to the individual lines towed and this helps the skipper to alert the crew to take care of a particular line which has caught the fish and thus no time is lost.

The lines on the port side boom are named (1) Kuttia, (2) Parai, (3) Kalal Kuttia and (4) Mukku Kuttia respectively and the lines on the star board side boom are termed (1) Kotta, (2) Kandha, (3) Emden and (4) Kuttia. The line on the sail boom rope is called Etta Kalai.

When the lines start fishing the skipper gives tak on the starboard or Port side as the case may be to ease the strain on a particular side line and shouts the name of the line in which the fish is caught. The crew who is in charge and is allotted the particular line immediately is alerted to attend to the particular line.

Whiffing line fishing off Tuticorin and in the area north of Gulf of Mannar is very effective during the months of August, September and October.

Catches are usually, *Thunus* sp., Seer, *Caranx*, *Chorinemus, etc.*

Best catches are observed to be between 8 a.m. to 10 a.m. before the sun becomes warm. The hook lure used by the Tuticorin trollers and the shining snoods are believed to attract the fish from long distances which chase and catch the bait on the move.

By this gear the bigger Tunas are also landed specially in the grounds close to deeper waters 10–15 miles from the coast.

Occasionally *E. affinis* is landed in the shore seines off Ramnad Coast, while operating south of the island rows in the Gulf of Mannar. Up to 200 numbers have been recorded in a single haul, each weighing about 10–15 lb. In the Palk Bay *E. affinis* is totally unknown. The Drift netters and set net fishermen have not landed this fish. However, in certain grounds close to Thalaimannar in the Ceylon Coast and north-west of Jaffna this species has been landed in drift nets of bigger mesh size. These are called in Ceylon "Bhalliya".

In the Coromandel coast *E. affinis* is also landed in Trolling lines and long line. The catamaran fishermen who return from other types of fishing usually set out 3–4 lines when they make the homeward journey and in this Tuna is caught . This is locally called the "Mela Kada Soorai" because it is landed in deeper waters and are caught along with sail fish, seer, etc. During August, September and October, off Madras fishermen operate long line with No. 4 and 5 hooks baited with squid. Four hundred hooks are laid by a catamaran in 15–20 fathoms when this fish is caught in better quantities.

The bigger members of the Tuna group caught in Madras coast are *Neothunnus macropterus* and *Kishinoella tonggol* popularly called "Ettalai" and "Kilavalai" respectively. These fish weigh 40–100 lb. and are very fast swimmers occurring in fishing grounds adjacent to deep waters. In Kanyakumari district *K. tonggol* is even landed in the shore seine net in the fishing villages of Thengapattinam, Thoothur and Enayam Puthenthurai during September-October. When schools of the bigger varieties are noticed and the fishermen get ready for encircling the bigger Tunas, they usually fix a strong bag or bunt to their shore seine made of twisted rope of about 3 m.m. thick in 5″ mesh size.

In the Gulf of Mannar *N. macropterus* and *K. tonggol* are commonly landed only in whiffing line. Mackerel is the bait that attracts this fish better. Tuticorin and Kilakarai Trolling fishermen carry strong lines for this fish and good numbers are landed during August–October.

The Palk Bay is devoid of this fishery.

In the Coromandel coast, *T. macropterus* is landed mostly in whiffing lines in 15–20 fathoms. But this is also caught in the long line set baited with squid. No. 4 or 5 hooks are used and a set of 400 hooks are used set higher in the column by adjusting the boats.

Tunas do not have much of market value as a table fish. Many people do not relish the blood red colour of the flesh of Tuna. But as cured fish it has a good value in Ceylon.

"Masi" or "Maldve Fish" is a special preservative preparation of the Tuna flesh. By this, the flesh is cut into fillets of about 8″×2″×2″ and are half-cooked in steam. Then these are rolled in salt water or salt and kept in canvas or gunny and twisted to squeeze out the water content. Then they are kept in grills and smoked to dry. A well prepared "Masi" is light brown in colour, hard and fibrous. Cured Tuna in this way has a very high value in Ceylon and it is esteemed as a high delicacy by the Ceylonese.

"Masi" is prepared in small quantities at Kilakarai more for domestic use by experienced curers who have been in Ceylon before.

Proper exploitation of Tuna sp. have not been done in deeper waters. Study and information in this field is wanting.

With the aid of fast sea worthy decked boats, Drift Tuna line could be attempted from Tuticorin base. Tuna Drift lines baited with Mackerel or squid should be attempted during August–October in about 200 fathoms off Tuticorin or Kanyakumari Coast along commercial lines to assess the productivity of our seas for this fishery.

**Bill Fish.**

Bill fishes are usually deep water varieties and often occur along with the deep water Tuna. In the Madras State the sail fish and marlins do not form an important fishery because of the comparatively insignificant landings and the poor sale value. These fishes are caught both in the Coromandel and Gulf of Manar coasts in Trolling lines in grounds adjacent to deeper waters.

The common Bill Fish, *Istiophorus sp.* is landed in Gulf of Mannar during the months of September–November in trolling lines along with Tuna sp. Occasionally these are also landed in the drift nets by rolling in the webbing during October–November. The size range is about 5′–6′ weighing 65–90 lb. In the Coromandel coast, Sail fish, and marlins are landed occasionally in the trolling lines during August–September. This is popularly called "Olai Meen" or "Pani Meen" and the fishermen dread the fish because of its fierce snout which is likely to hurt them when the fish spins full speed on a line and is landed in the canoe.

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# BIOLOGY AND FISHERIES OF MYSTUS (OSTEOBAGARUS) AOR (SYKES) IN THE BHAVANISAGAR RESERVOIR

BY

SRI V. RANGANATHAN AND KUMARI N.V. RADHA, FRESH WATER BIOLOGICAL RESEARCH STATION, BHAVANISAGAR.

Any plan of fishery development in the major artificial impoundments of our river systems will have to be centred around a scientific management formulated on biological data of each fish population. The biology of one such population *Barbus dubius* [Ranganathan *et al* (1963)] in the Bhavanisagar reservoir has thrown considerable light on the abundance of this species in reservoirs similar to Bhavanisagar and its disappearance from reservoirs like Mettur Dam. The suitability of utilising this species with success in other impoundments of our State for stocking has also been discussed.

*Mystus* (*Osteobagarus*) *aor* (Sykes) along with a smaller percentage of *Mystus* (*Osteobagarus*) *seenghala* (Sykes) is a fishery of considerable importance in the rivers and reservoirs of the Cauvery System of Madras State. Going by the local Tamil names குருந்தலை கெளுத்தி and நெடுந்தலை கெளுத்தி the fish is priced as a table fish of few bones compared to other fishes of the reservoir landings.

TABLE I.

*Year-war landings of* Mystus *species by the two experimental units at Bhavanisagar.*

| Year. | Total landings. | Landings of Mystus aor | |
|---|---|---|---|
| | | *Number.* | *Weight.* |
| | KGS. | | KGS. |
| 1959–60 .. | 18,634 | .. | .. |
| 1960–61 .. | 16,969 | 2,156 | 4,724·98 |
| 1961–62 .. | 28,565 | 2,435 | 5,161·00 |
| 1962–63 .. | 17,770 | 1,700 | 3,957·75 |
| 1963–64 .. | 44,770 | 6,768 | 11,068·00 |

TABLE II.

*Total estimated landings and the quantity of* Mystus *species landed by the licencees in Mettur Reservoir.*

| | *Total landings.* | *Quantity of* Mystus *species landed.* |
|---|---|---|
| | KGS. | KGS. |
| 1961 .. .. .. | 2,33,922 | 22,632 |
| 1962 .. .. .. | 2,85,057 | 24,436 |
| 1963 .. .. .. | 4,54,427 | 35,835 |

Tables I and II show the year-war landings of these two species by the two experimental units using on an average 1,500 fathoms of Rangoon nets during 1959 to 1963 in Bhavanisagar and the landings at Mettur by the licencees. The catches do not indicate the trend in increase or decrease because the catch efficiency was not uniform and the condition of the nets, etc., varied due to administrative reasons. Of the computed landings of 1,924 metric tons from the regulators of the Cauvery System in Tanjore delta in 1961, 7·8 per cent was that of *Mystus aor* and *Mystus seenghala*.

The biology of this fishery with special reference to reservoir conditions is little known. The account of the extraordinary breeding habits by Sunder Raj (1962), the life history, bionomics and breeding habits by Saigal and Motwani (1962) are all under riverine conditions. The present study of this fish population in Bhavanisagar is for assessing its trend in all our reservoirs where it exists and following a planting practice in other reservoirs, of the same type once its biology is known.

## MATERIAL AND METHODS

These observations are based on the data collected from the daily landings of the experimental units operated in the Bhavanisagar reservoir since 1959. The data on food, and feeding habits, age and growth, gonadial maturity, breeding habits and condition factor are with reference to this ecological niche. Simultaneously the otoliths and vertebral bones were taken out as detailed below prepared and radial measurements recorded. Opercular bones also exhibited definite age rings in their margins, yet they were not used for the study. The otoliths are lifted from the floor of the skull after exposing and scraping off of the soft brain. The enveloping sacs are removed by manipulation of the forceps and the exposed sagittae are then wiped clean by rubbing gently with fingers. After cleaning with 5 per cent potassium hydroxide, they are slightly grained on a smooth stone with coconut oil. Glycerine and xylol wash improves examination. The vertebrae are obtained by boiling the anterior portion of the vertebral column for 15 minutes washing in running water and drying in sun light the individual vertebra. Sections taken out of a fret work saw and treated for 24 hours respectively with acetone and xylol exhibit clearly age rings for record of measurements.

## FOOD AND FEEDING HABITS

Stomach contents of specimens examined in the year 1961 and 1962 are summarised in the table below :—

| *Months of collection.* | *Number examined.* | *Range in length.* | *Percentage feed.* | *Stomach contents.* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| January .. .. .. .. | 26 | 480 to 770 | empty to ·2 | Small fish, rotifers, fresh water oligochaetes. |
| February .. .. .. .. | 29 | 420 to 740 | ·4 to ·9 | Chironomid, May fly nymph, fresh water oligochaetes. |
| March .. .. .. .. | 21 | 440 to 770 | ·5 to full. | Chironomid, May fly nymph, fresh water oligochaetes. |
| April .. .. .. .. | 18 | 360 to 780 | ·6 to full. | Chironomid, May fly nymph, fresh water oligochaetes. |

| *Months of collection.*<br>(1) | *Number examined.*<br>(2) | *Range in length.*<br>(3) | *Percentage feed.*<br>(4) | *Stomach contents.*<br>(5) |
|---|---|---|---|---|
| May | 27 | 420 to 760 | ·7 to full. | Chironomid, May fly nymph, fresh water oligochaete. |
| June | 26 | 380 to 700 | ·2 to ·8 | Rotifers, crustacean eggs, small fish, insect remains. |
| July | 28 | 300 to 680 | ·2 to ·8 | Rotifers, crustacean eggs, small fish, insect remains and molluscan remains. |
| August | 24 | 480 to 730 | empty to ·6 | Rotifers, custacean eggs, small fish and copepods. |
| September | 28 | 398 to 740 | empty to ·4 | Copepods, rotifers, small fish. |
| October | 24 | 460 to 740 | ·1 to full. | Diatoms, half digested fish Rotifers filamentous algae. |
| November | 28 | 480 to 720 | empty to ·5 | Digested fish, worm remains. |
| December | 24 | 480 to 770 | empty to ·3 | Digested small fish, worm remains. |

The fish is piscivorous. In addition it browses on the mud flats and feeds on May fly nymphs, molluscs, and other benthic fauna including oligochaetes. The presence of Rotifers, diatoms and copepods usually represented in the reservoir plankton in the stomach indicated additional plankton feeding. During the pre spawning and post spawning season the percentage of feed is less. From February onwards, the post spawners resort to active feeding along the margins and in shallower areas on chironomids May fly nymphs and benthic oligochaetes.

## THE FISHERY

*Mystus aor* with *Mystus seenghala* is the second important fishery of Bhavanisagar reservoir, an artificial impoundment, 30 square miles in extent (Ranganathan, *et al* 1963).

Text Fig. 1 is an indication of the monthly landings by the two experimental units of 2 coracles and four fishermen. The Bhavani and the Moyar rivers, the major tributaries of the Cauvery, before impoundment, were inhabited by this species, and thus the reservoir started with a natural impounded stock.

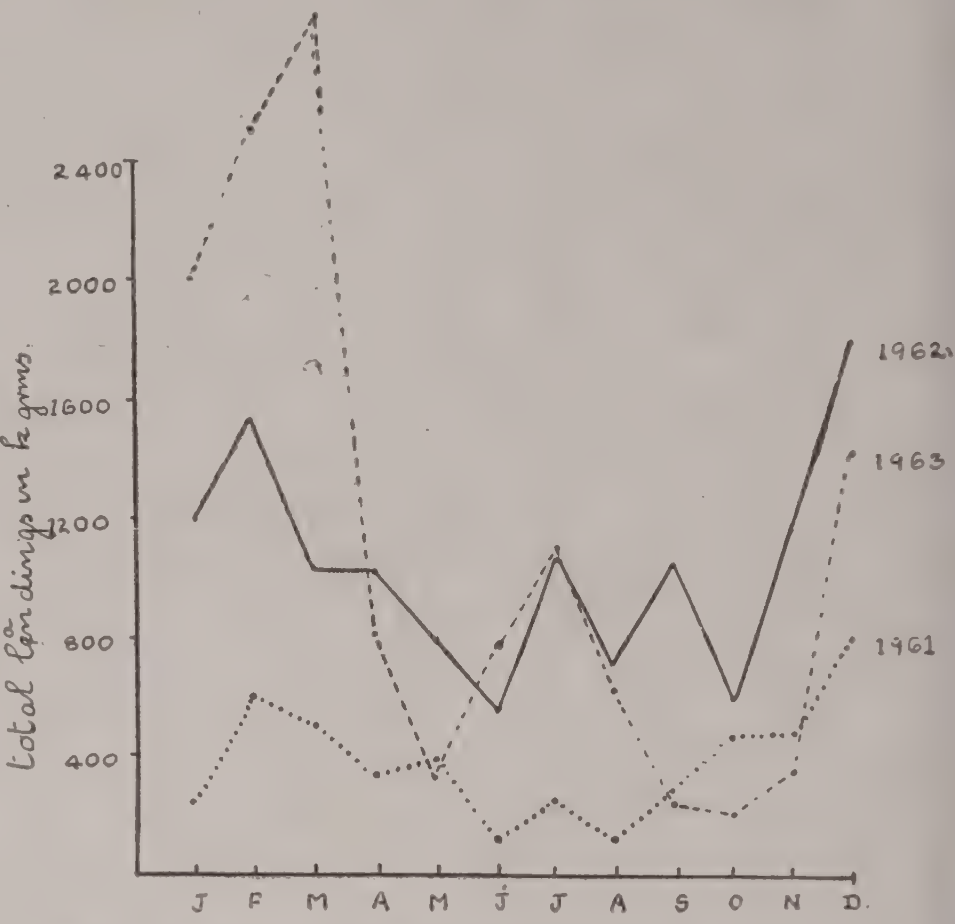


FIG. 1—*Mystus aor*—Monthwar landings of the two experimental units of Bhavanisagar reservoir from 1961-63.

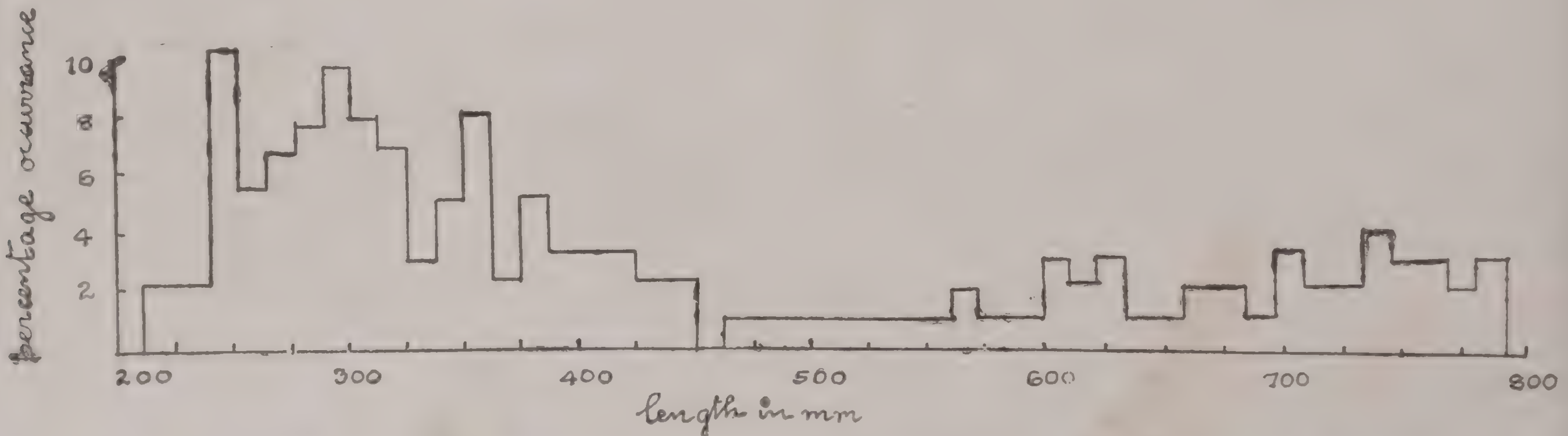


FIG 2—*Mystus aor*—Length frequency histogram of landings in 1962. (Bhavanisagar reservoir).

Text Fig. 2 is the length frequency diagram of the landings in one month in 1962. The evidence of increase in age and additional age groups is a clear proof of the firm establishment of this fishery in the Bhavanisagar reservoir (photo 5).

From the experience gathered in Mettur, and through a system of licencing and co-operative marketing as done therein an annual fishery of 75 to 100 tons is anticipated to be fished from Bhavanisagar commercially.

The successful tackles used were "Rangoon nets". They are fabricated locally from synthetic yarn equated to Terelyne code 1 and 2. Each standard net is 35 meshes deep and 100 meshes long, each mesh being 4·5 cms. knot to knot. They are also landed by Uduvalais—bottom set nets 15 meshes deep, 4,000 meshes long, each mesh of 4·5 cms. with tubular cane floats set at intervals of 100 cms. and earthern ball weights. One end of this net is fixed to the water fringe and the other end let free in the reservoir. The fishes are also landed on hook and lines by poachers. Text figure 1 indicates the intensity of the fishery in the different months of the year. Around the breeding season from November onwards to March-April we get an intensified fishery. The increase in catches are due to the upward migration to the top waters till March. From March to May the nets are laid to advantage in shallower fringes where the post spawners move in numbers apparently for active feeding on nymph and benthic fauna. The Moyar side of the reservoir has a richer population of the fish than the Bhavani side. An interesting observation is that, this fishery accounted for 13 to 15 per cent by weight in 1951 in Mettur reservoir as against 10 per cent in 1961. The reason for this decrease in population allowing for limitations in catching method and level in reservoir is discussed elsewhere.

## AGE AND GROWTH

The necessity for the study of the year class composition of any fishery over a stretch of many years is evident. Before the formation of the reservoir, the riverine area was prone only to sporadic floods, alternated by low water conditions and exposed to heavy fishing and dynamiting. The maximum age group was then limited to 300 to 420 mm. With the permanent expanse of water and repopulation facility the frequency pattern got extended to the seven-year class of 740 to 770 mm. In view of the limitations imposed by the fishing method, interpretation of the histogram for estimating extent of repopulation or fishing is not attempted. Agreement with Petersen's method is one of the tests of validity for the use of any structure for age and growth determinations. In a population of a species of fish having a single restricted spawning season the individual length of fish of each age group is approximately normally distributed and the modes of length frequency distribution of successive age groups in a sample are separated along the length axis. In *Mystus aor* these conditions are satisfied in that it has a single spawning season (February-April). Figure 2 is a frequency polygon of 600 specimens of *Mystus aor* collected in one month. The different age groups in the polymodel frequency distribution were separated by the use of probability paper. When interpreted the range of length reached by the fishes at the end of each year is—

I year—240 mm.
II year—260 to 330 mm.
III year—340 to 400 mm.
IV year—400 to 530 mm.
V year—520 to 630 mm.
VI year—640 to 700 mm.
VII year—700 to 770 mm.

The fact that tropical fishes also show periodical "checks" (rings) on their discrete hard parts has been demonstrated in a few Indian species [Seshappa and Bhimachar (1951, 1954 and 1955)]. It was found in the course of the investigations that there were distinct zones, viz., rings in the otoliths of the cat fish, *Mystus aor*. It was first assumed that the zones on the otoliths were annual and the age determined from the number of zones was compared with the estimates of growth obtained from the Petersen's method of tracing the length frequency modes. To test the assumption that the zones were annual, a study of the growth at the edge of the otolith according to the season was made. The otoliths of *Mystus aor* are oval in shape with one convex and one flat or slightly concave surface. The oval shape tends to become irregular in the older specimens with calcified concretions protruding on the sides. For estimating the age the convex side was invariably used because the other side is grooved and modified for the passage of the auditory nerve. Before examination the concave side is slightly ground and then kept in a watchglass with enough water to cover for examination under binocular lens. One hundred and fifty specimens were aged like this. The observed mean length of the fishes examined, their range, the number of annual rings in the otoliths and the radius of the otolith from the central point to the age line are shown in the Table 2.

TABLE 2.

| *Serial number.* (1) | *Number of rings.* (2) | *Radius of rings.* (3) | *Range of length in mm.* (4) | *Mean length of fish in mm.* (5) | *Age in year.* (6) |
|---|---|---|---|---|---|
| 1 | 2 | 2·2 | 260–340 | 314 | II |
| 2 | 3 | 2·4 | 320–390 | 380 | III |
| 3 | 4 | 2·75 | 380–520 | 488 | IV |
| 4 | 5 | 3·35 | 510–630 | 622 | V |
| 5 | 6 | 3·7 | 620–710 | 699 | VI |
| 6 | 7 | 3·9 | 720–770 | 756 | VII |

Fishes below 260 mm. were not available in the commercial catches.

Figure 3 is a scatter diagram showing a linear relationship between the length of otoliths in mm. and the total length of the fish in mm. The equation expressing the linear relationships $y = a + bx$ was applied to derive the regression formula where $y$=the total length of the fish $x$=length of the otolith and $a$ and $b$ are constants. In the case of *Mystus aor* during the present studies the formula worked out to be $y=22{\cdot}64+124{\cdot}14x$. The back calculated length of fish using this regression equation at the formation of various otolith rings worked out as 278·24 mm., 328 mm., 379 mm., 467 mm., 629 mm., 697 mm. and 757 mm., at the end of the I, II, III, IV, V, VI, and VII year respectively The fair amount of agreement between the length obtained by length frequency studies, by otolith grouping and back calculated length is seen in the Table 3.

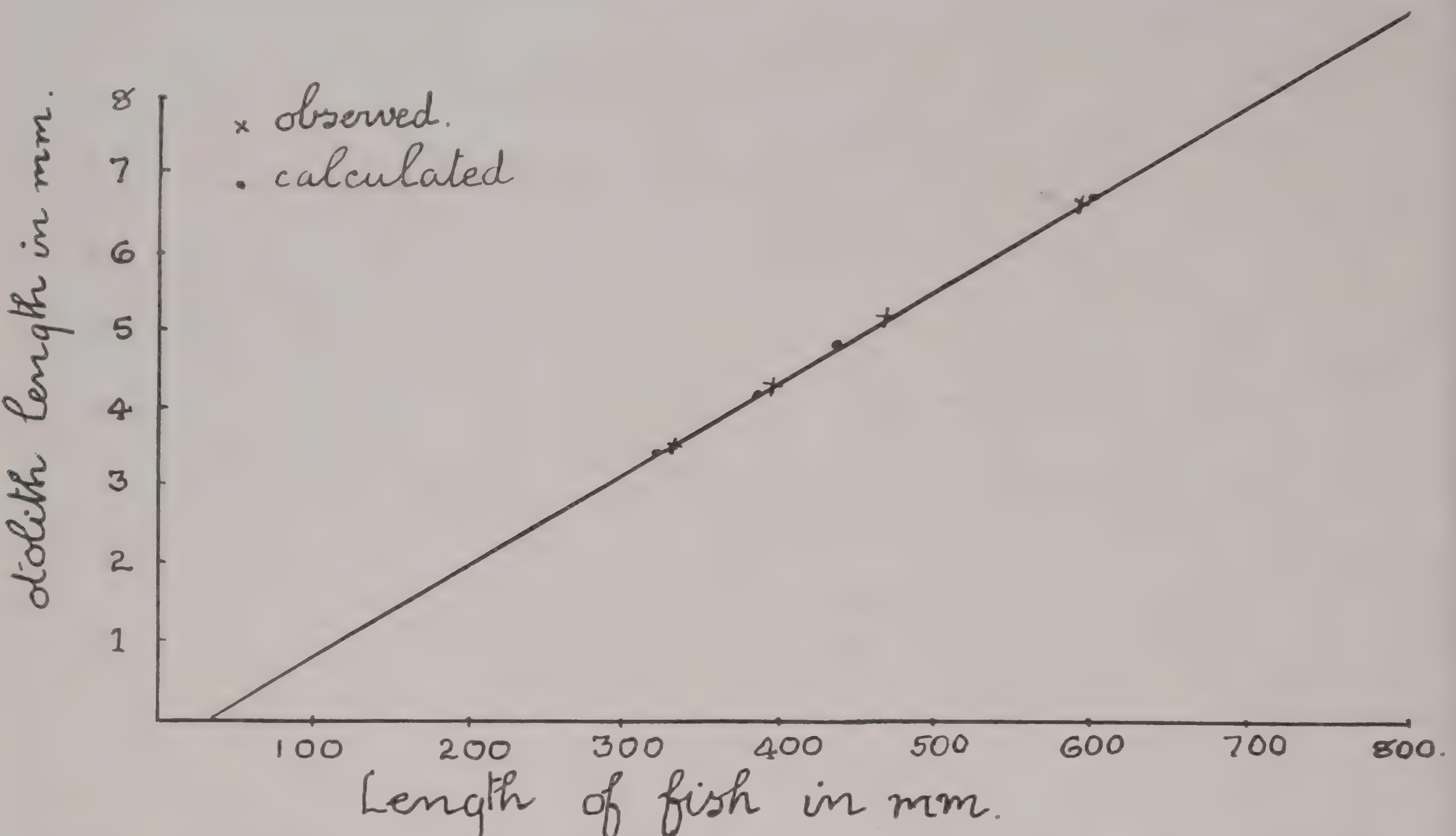


FIG. 3—*Mystus aor*—Scatter diagrams showing linear relationship between length of the otolith in mm. and the total length of the fish in mm.

TABLE 3.

| *Serial number.* | *Age in year.* | *Mean length by length frequency in m.m.* | *Mean length by otoliths in m.m.* | *Back calculated length in m.m.* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| 1 | I | 240 | .. | 278 |
| 2 | II | 300 | 314 | 328 |
| 3 | III | 390 | 380 | 379 |
| 4 | IV | 490 | 488 | 467 |
| 5 | V | 620 | 622 | 618 |
| 6 | VI | 700 | 699 | 697 |
| 7 | VII | 740 | 756 | 757 |

Figure 4 illustrates this comparison and the linear relationships very clearly.

Yoship Hiyama and Ryushi Ichikawa (1952) made use of the rings in the vertebrae of fish for estimating the age of fish in addition to scale estimation as an independent factor for comparisons. The vertebrae of *Mystus aor* show definite age rings (Photos 1 to 4) Sections of vertebrae of 150 specimens were prepared and carefully aged. The clean vertebrae were examined against a powerful lens. The radius and the diameter were measured with an ocular micrometer noting simultaneously the number of rings. The straight line relationship of the scatter diagram between the length of the fish on one axis and the radius of the vertebrae on the other met with in the otolith study was also evident here.

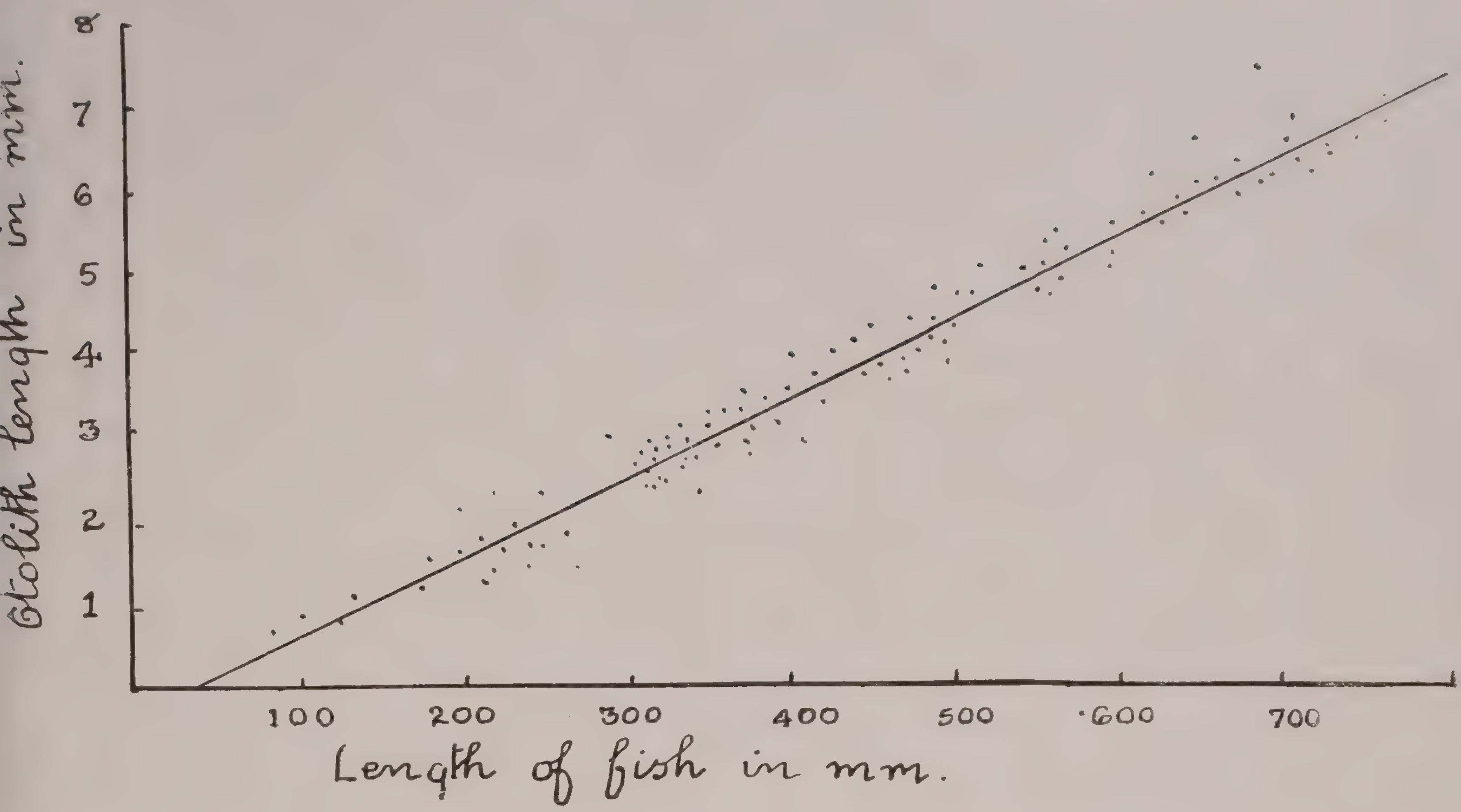


FIG. 4—*Mystus aor*—Comparison of linear relation between otolith and mean grouped length and back calculated length.

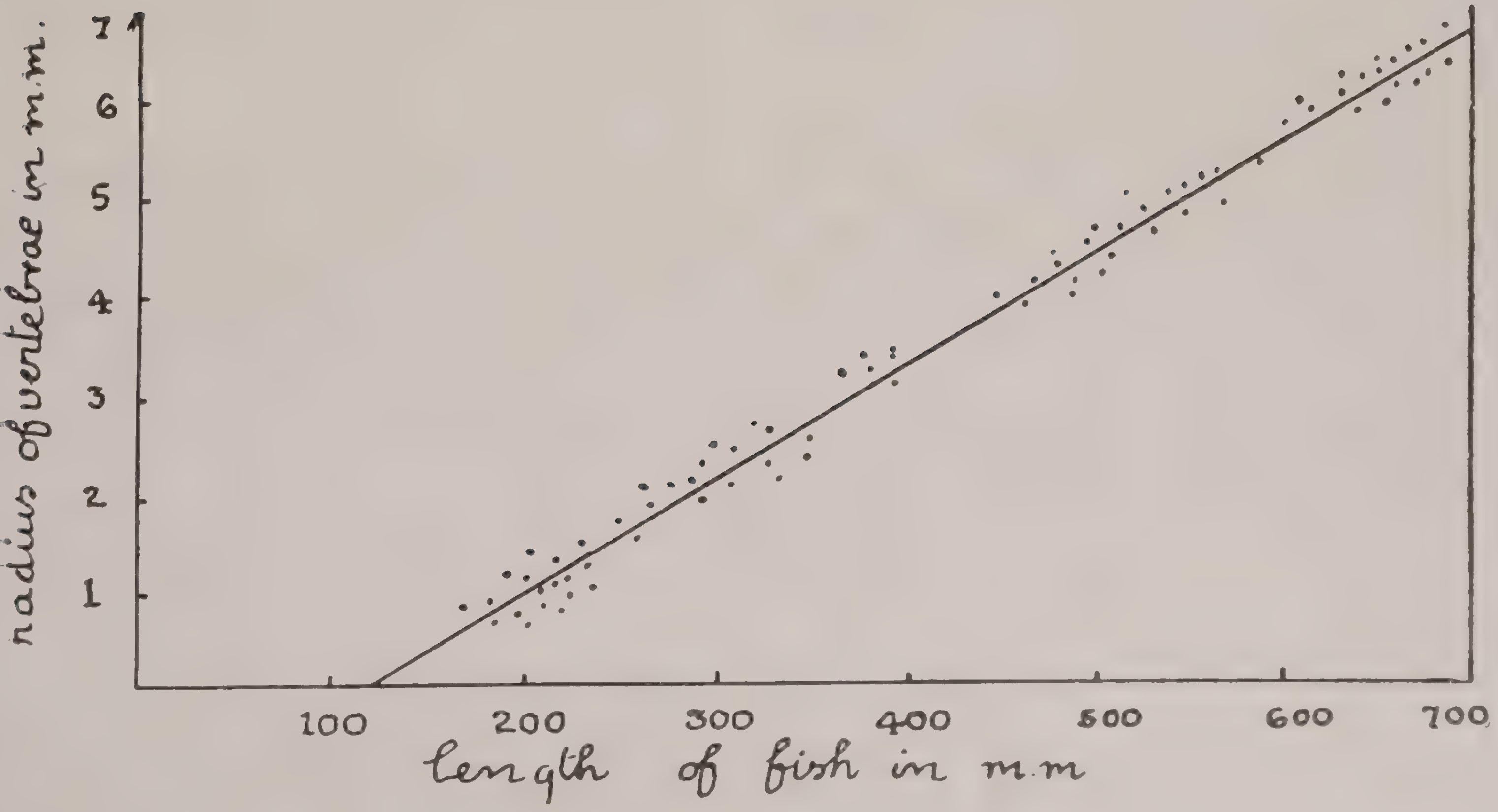


FIG. 5—*Mystus aor*—Scatter diagram showing linear relationship between the radius of vertebrae and the total length of fish.

The observed mean length of the fish in mm. and its relationship to the vertebrae rings are expressed in the table below :—

TABLE 4.

| *Number of rings.* | *Radius of vertebrae in mm.* | *Mean length of fish.* | *Range of length of fish.* |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 1 | 1·1 | 231 | 0–250 |
| 2 | 1·1 | 231 | 240–330 |
| 3 | 2·5 | 345 | 320–380 |
| 4 | 4·0 | 502 | 390–520 |
| 5 | 5·5 | 621 | 510–630 |
| 6 | 6·0 | 667 | 620–690 |

The regression formula of the equation $y=a+bx$ where $x$ is the radius of the vertebrae, $y$=length of the fish and $a$ and $b$ are constants, was calculated as $y=123{\cdot}5+90{\cdot}65\,x$ for these studies. The back calculated length of the fish for different year class on this fomula worked out to be I year 214·15 mm. ; II year 304·8 mm. ; III year 359·19 mm. ; IV year 449.84 mm. ; V year 567·75 mm. ; and VI year 667·4 mm. The close amount of agreement in the estimation of age and length of *Mystus aor* arrived at, by the otolith and vertebral study is seen clearly in the table below and Figure 6.

TABLE 5.

| *Serial number.* | *Mean length by histogram.* | *Mean length by otolith.* | *Mean length by vertebrae.* | *Number of rings.* | *Back calculated length.* |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1 | 240 | .. | 230 | 1 | 214 |
| 2 | 300 | 314 | 293 | 2 | 305 |
| 3 | 390 | 380 | 358 | 3 | 359 |
| 4 | 490 | 488 | 374 | 4 | 450 |
| 5 | 620 | 622 | 570 | 5 | 577 |
| 6 | 700 | 699 | 663 | 6 | 667 |
| 7 | 745 | 756 | .. | 7 | .. |

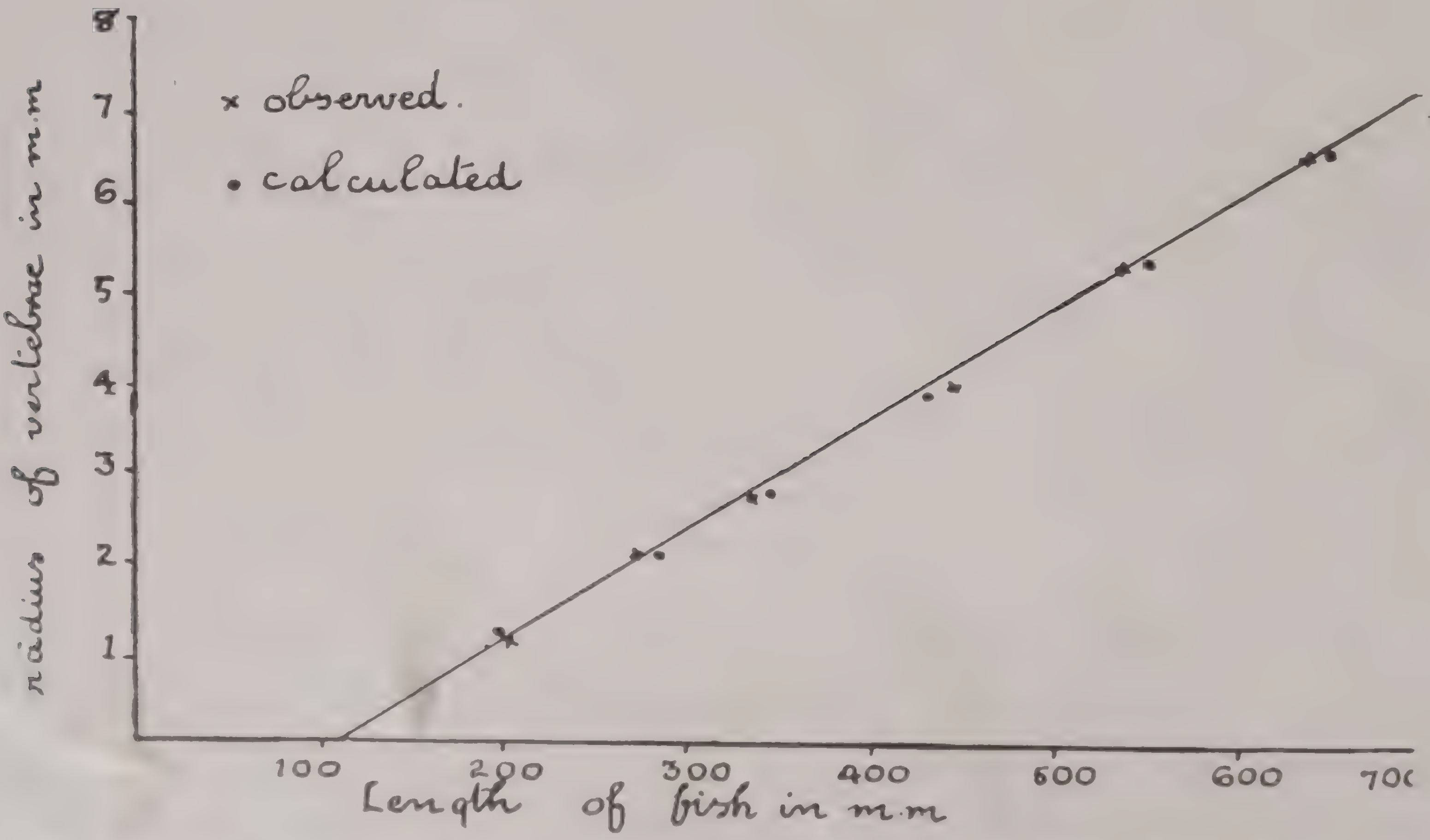


FIG. 6—*Mystus aor*—Comparison of linear relationship between vertebrae radius and back calculated lengths.

Figure 7 illustrates the age and growth of *Mystus aor* in length and its increment at the end of each year.

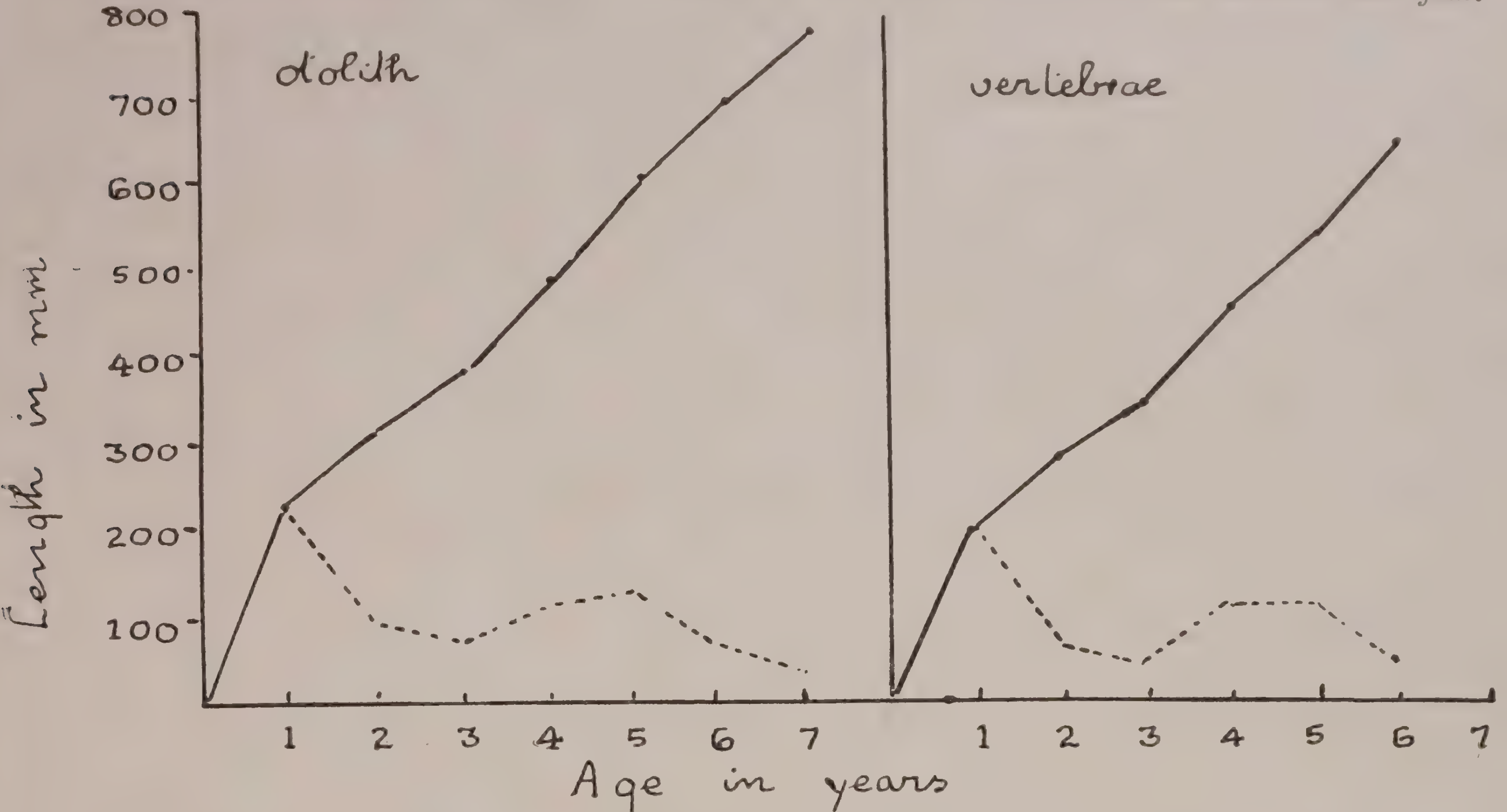


FIG. 7—*Mystus aor*—Relationship between age and growth in length.

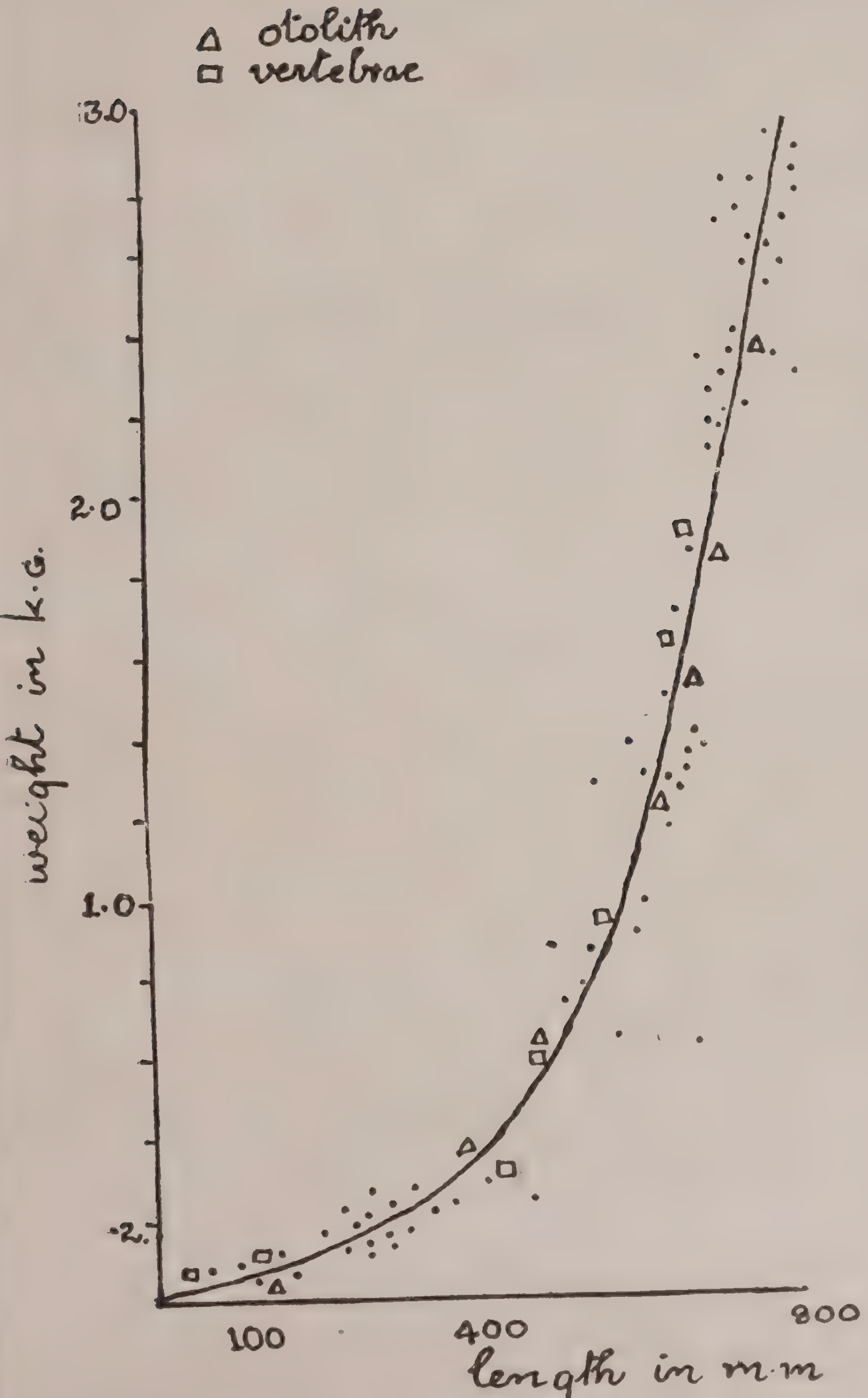


FIG. 8—***Mystus aor***—Relationship between length and weight.

It is seen that the general increase in length of the I and II year decreases in the III year and then it increases up to the fifth year. There is a gradual decrease afterwards.

## LENGTH-WEIGHT RELATIONSHIP

Le Cren (1947) has reviewed in detail the methods employed in estimating the length-weight relationship of fishes with a clear exposition of the superiority of the equation W=Cln. A scatter diagram of weight on length (Figure 8) suggested that this relationship in the case of *Mystus aor* confirmed to this general formula where W=weight of the fish, L= length of the fish and 'c' and 'n' are constants.

The data gathered from the entire years landings from Bhavanisagar Reservoir of *Mystus aor* ranging from 240 to 780 mm. were divided into five groups. The average weight and length of each group was taken up for calculation. In the present work in the case of *Mystus aor* the constants worked out to be c=6·579 and n=3·492 and the logarithmic equation

$$\text{Log } w = -6{\cdot}579 + 3{\cdot}492 \log L.$$

Figure 8 is a scatter diagram of the absolute value of length and weight and Figure 9 is linear being the regression of log weight on log length.

Figure 10 exhibits the relationship between mean length of fish and mean weight.

Table 7 shows the growth in weight of *Mystus aor* at the end of each year and its increment. It shows that the growth in weight gradually increases up to the fifth year after which there is a decrease.

TABLE 7.

| *Number.* | *Age in years.* | *Mean weight in grams.* | *Increase of weight in grams.* |
|---|---|---|---|
| 1 | I | 100 | .. |
| 2 | II | 213 | 113 |
| 3 | III | 329 | 116 |
| 4 | IV | 644 | 325 |
| 5 | V | 1,392 | 748 |
| 6 | VI | 2,006 | 614 |
| 7 | VII | 2,380 | 374 |

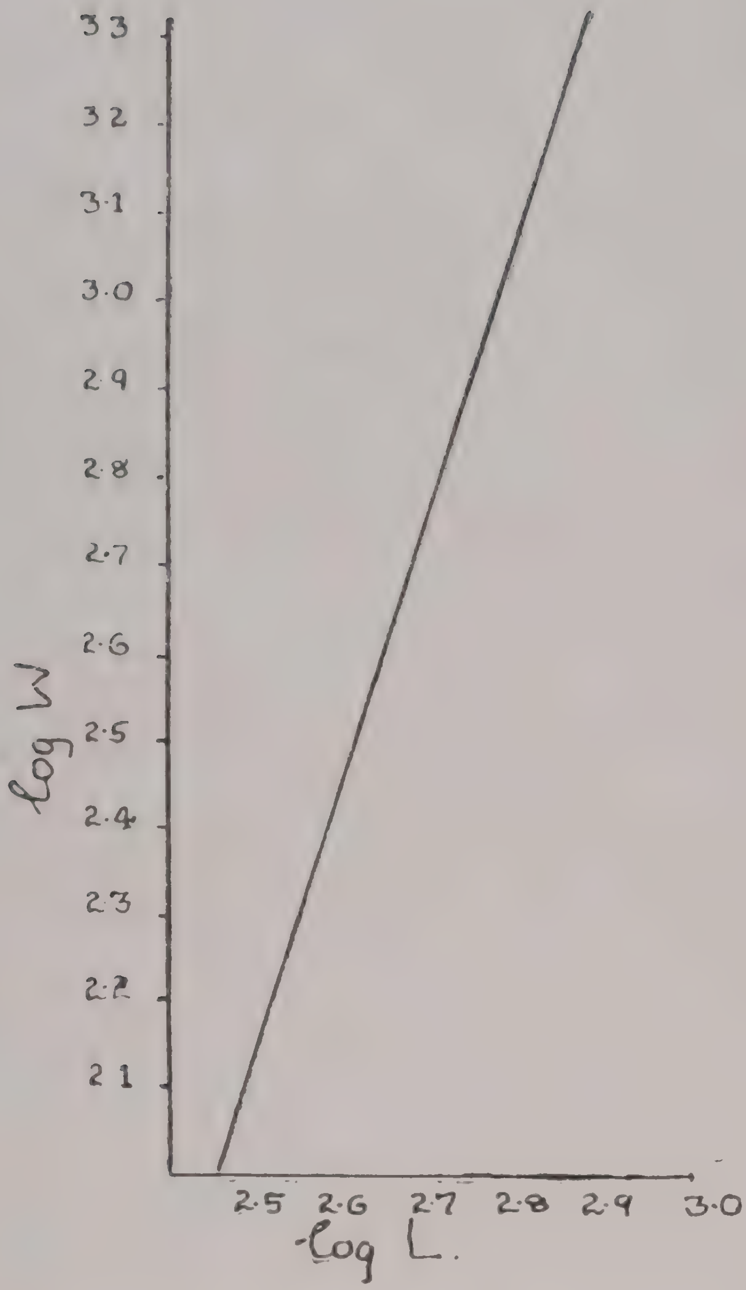


FIG. 9—*Mystus aor*—Linear straight line of log length by log weight.

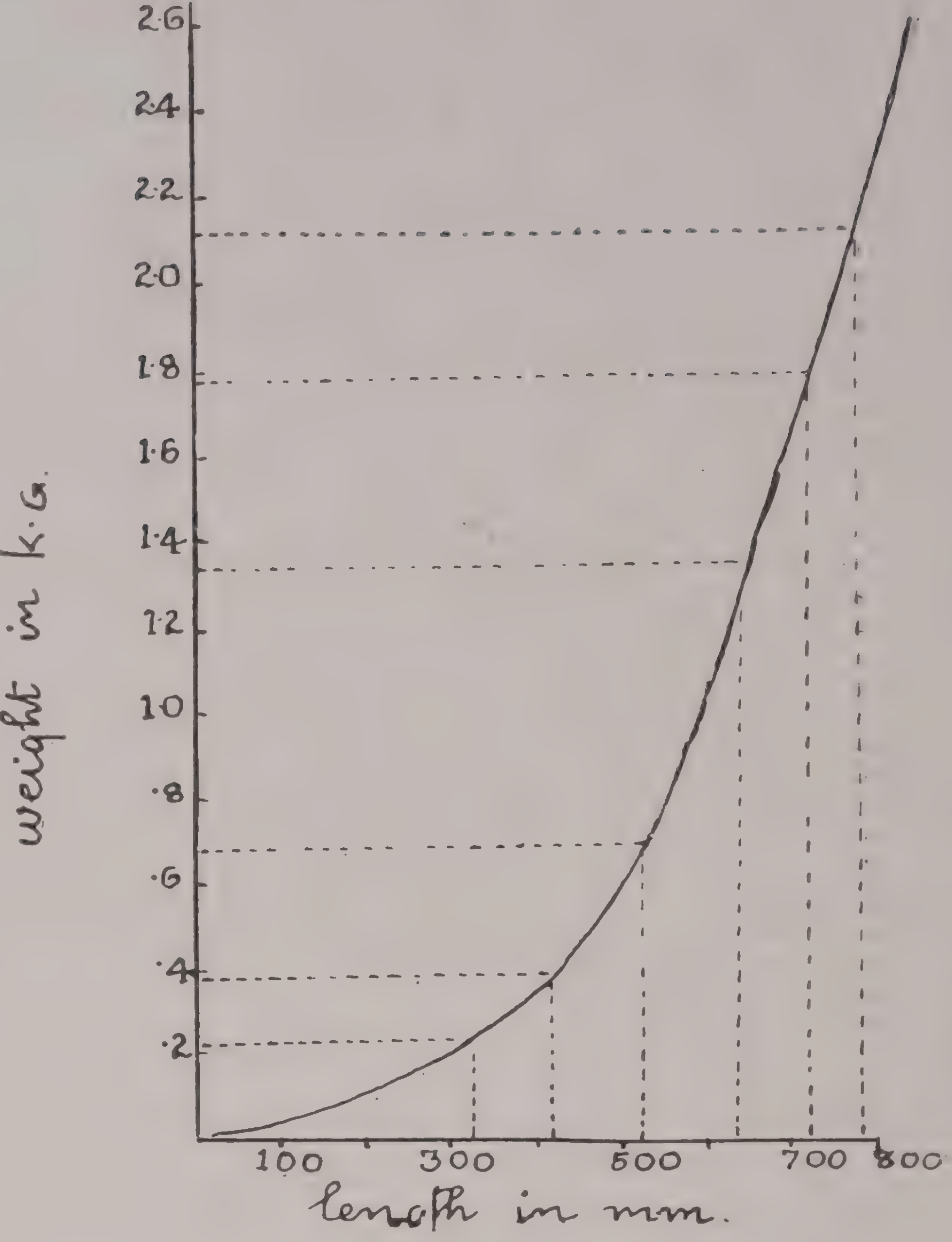


FIG. 10—*Mystus aor*—Relationship between mean length and mean weight.

## RELATIVE CONDITION

A complete discussion on the relative condition with reference to season, sex and maturity will be taken up at a later stage. The general formula $K = W \times \frac{10^5}{L3}$ was applied.

| *Number.* | *Length in mm.* | *Weight in grms.* | $K = W \times \frac{10^5}{L3}$ |
|---|---|---|---|
| 1 | 314 | 213 | 0·6882 |
| 2 | 380 | 329 | 0·995 |
| 3 | 488 | 644 | 0·5543 |
| 4 | 622 | 1,392 | 0·5784 |
| 5 | 699 | 2,006 | 0·5872 |
| 6 | 756 | 2,382 | 0·5509 |

In this initial study there was no marked difference between the female and male Kn factor. The relative condition is below 1 in all the fishes. This is naturally to be expected because of the linear shape. It shows that the relative condition decreases up to fourth year and onwards there is an increase. It is yet to be confirmed whether this inflection in the IV year is an indication of attainment of sexual maturity.

## MATURATION—FECUNDITY AND SPAWNING

The sexes are separate. There is no special mention of the morphological characters distinguishing the male and female either by Sundar Raj (1962) or Saigal and Motwani Satyanesan's (1962) account of the presence of papilla in the males of *Mystus aor* does not carry conviction of a clear differenciation. Pantulu (1961) sexes out male *Mystus gulio* by the well defined protruberance with a free tapering end and the females by the separate urinogenital opening. Tom Moen (1949) has successfully sexed the channel cat fish *Ictalurus punctatus* (Rafinesque) with the aid of a probe, where in the female cat fish, the urinary and genital ducts have separate external openings while in males these ducts have only one opening. The use of a probe to separate sexes in both *Mystus aor* and *Mystus seenghala* especially during the breeding months was successful. In addition all the male specimens examined had a pair of flap (Fig. 1) like structure behind the anal orifice. Each flap was 2 to 2·2 mm. by 4 to 4·5 mm. depending on the size and age of the adult. In the commercial catches of Bhavanisagar fishes above 350 mm. in male and 450 mm. in females above were mature. The II stage is reached in the female by November and by January to February they reach IV stage. As maturity advances the yellow fat reserves in the coelom get absorbed. By February the mature females and males start on upward migration towards the top waters of Moyar in Bhavanisagar and Pannavadi in Mettur. The confluence between the riverine and the lacustrine area is now full of migrating breeders.

Compared to carps the fecundity of the fish is poor and evidently so because of the highly evolved parental care.

The following are the estimated number of ovarian eggs from 10 different females of *Mystus aor* in March 1962 :—

| *Serial number.* (1) | *Total length.* (2) | *Total weight.* (3) | *Weight of gonad.* (4) | *Volume of gonad.* (5) (*in c.c.*) | *Estimated eggs.* (6) |
|---|---|---|---|---|---|
| 1 | 775 | 2,800 | 17·5 | 17·5 | 26,250 |
| 2 | 785 | 2,900 | 19·2 | 18·5 | 27,840 |
| 3 | 770 | 3,100 | 25·0 | 21·1 | 34,380 |
| 4 | 770 | 2,925 | 25·0 | 22·2 | 33,100 |
| 5 | 750 | 2,725 | 20·0 | 18·4 | 22,000 |
| 6 | 773 | 3,275 | 28·0 | 24·0 | 38,400 |
| 7 | 780 | 3,200 | 22·5 | 19·0 | 23,480 |
| 8 | 680 | 2,267 | 16·8 | 17·0 | 26,420 |
| 9 | 640 | 2,040 | 17·0 | 17·2 | 28,240 |
| 10 | 620 | 1,584 | 16·6 | 17·3 | 21,490 |

The ripe ova are orange yellow in colour. The diameter of the unfertilized egg varies from 1·76 m.m. to 2·1 m.m.

Sundar Raj (1962) and Saigal and Motwani (1962) have discussed in length the breeding habits of the fish under riverine conditions. According to both the breeding seasons extend from April to August. The breeding seasons in Bhavanisagar is from end of February to April-May, before the onset of the south-west floods. Under lacustrine conditions the fishes after attaining gonadial maturity start on a short upward migration towards the top waters. It is at once apparent that the presence of a fall sharply dividing the lacustrine area from the riverine area will be a barrier and will adversely affect the re-population trend. The favourite spawning grounds in Bhavanisagar is the Moyar side for a distance of 3 to 4 furlongs from the commencement of the reservoir area where a gentle and slow riverine flow is felt. The area consists of exposed mud flats all around and the sluggish muddy river in the centre, with a gentle flow of 300 to 400 cusecs. After a short play the nests are constructed, they, being saucer shaped pits ranging in size from 38 cm. to 60 cm. and with the central pit 18 cm. by 10 to 12 cm. wide. In spite of the heavy silt around, the nests are clear and on running the hand over, the surface is felt as though of fine mud plastered. The nests are usually constructed overhanging cliff, or tree stump or a stone or decaying tree trunk and are in waist to chest deep water. The 600 to 700 metre length of spawning ground is actually littered with a number of these nests and it will be impossible to cross the river in this stretch without stampeding the nests.

The following data furnished by the Assistant Director of Fisheries (Hydrology) gives an indication of the physico-chemical features :—

| Date of collection. | 18th March 1961. | 8th April 1961. | 12th February 1962. | 12th March 1962. | 30th April. 1963. |
|---|---|---|---|---|---|
| Time .. .. | 9·00 | 9·30 | 90·0 | 9·00 | 9·35 |
| Temp. °C. .. .. | 26·2 | 25·2 | 27·0 | 26·2 | 26·1 |
| Colour .. .. | C'less. | C'less. | C'less. | C'less. | C'less. |
| Odour .. .. | No. | No. | No. | No. | No |
| Turbidity .. .. | 30 | 30 | 30 | 30 | 30 |
| Weather .. | Bright sunshine and cool breeze. | | | | |
| Free $Co_2$ .. .. | Nil. | Nil. | Nil. | Nil. | Nil. |
| Carbonate .. .. | 3·0 | 3·0 | 3·0 | 3·0 | 1·5 |
| Bicarbonate .. | 4·7 | 5·1 | 92·4 | 51·8 | 51·8 |
| $p^H$ .. .. | 8·1 | 8·1 | 8·3 | 7·7 | 7·4 |
| Dissolved oxygen Mg/1. | 62 | 7·0 | 7·4 | 6·3 | 6·0 |
| Saturation (per cent). | 71·94 | 80·09 | .. | .. | 73·03 |
| $Po_4$ .. .. | Nil. | Nil. | Nil. | Nil. | Nil. |
| Silicate .. .. | 2·0 | 2·5 | 7·6 | 4·4 | 2·0 |
| Nitrate .. .. | Nil. | Nil. | Nil. | Nil. | Nil. |
| Chloride .. .. | 9·0 | 9·0 | 12·0 | 27·0 | 8· |

In spite of the flowing condition the quantity of dissolved oxygen is little compared to the usual record in the spawning grounds of major carps in tropical waters. All stages in the development of the fish have been collected from these nests including the early fertilised eggs, not reported to have been come across by Sundar Raj (1962) in the Bhavani river. As observed by all previous workers the male guards the brood. The females, after the play, are lethargic and are caught on their return migration by hand or in the Rangoon nets in the lacustrine area. The female post-spawners are easily identified by the red surface as a result of the play in the shallow areas and can be distinguished by the absence of the milky secretion of the males. Male specimens from the nest have been collected at various stages. As the time of care increases the inflammation of the ventral surface and the milky secretion are more prominent. The stage of embryo in the brood can be judged with some practice on an examination of the ventral surface of the guarding males. The males even when scared or when disturbed from the nest have a tendency to return to the nests to continue the watch. The brood is guarded for nearly 35 to 45 days when the juveniles reach 4·5 to 6 cms. Till that stage the juveniles move inside the pit in one group browsing the milky secretions of the ventral surface of the male. The presence of the brood from the hatchling stage in the pit can be felt when they come to browse our finger tips when inserted inside these nests, an observation recorded earlier. The young ones 4 cm. old when examined for stomach contents had copepods and a few phytoplankton.

There is no justification in the inference of Sundar Raj (1962) that the fertilised eggs are housed in the papilla like process as in the case of *M. gulio*. Early fertilised eggs from cleavage stage have been seen in the nests. One nest examined on 20th March 1963 had 12,462 fertilised eggs. As many as 4,700, 8 mm. stage hatchlings and 4,268, 2·8 cm. fry have been collected from each individual nest. The developmental stages of *Mystus aor* confirm to the description given by Saigal and Motwani (1962). The fertilised egg is 2·1 to 2·2 mm. in diameter, the zona radiata is adhesive and the perivitilline space occupies little space. The newly liberated hatchling is 4·2 to 4·5 mm. When they reach 8·00 to 8·5 mm. stage the yolk gets absorbed with a clear oral opening. One remarkable feature likely overlooked by previous workers is the presence of a four-lobed cluster of external gills projecting out from the last gill arch, one on each side (Figure 11). The circulation of the blood in the external gills is clear under the microscope. It has earlier been recorded that oxygen saturation is low, and with the silt laden water, these accessory external gills seem to be an adaptation. The development of external gills in fish embryos have been recorded in all elasmobranchs, Polypterous and Amia (1957) and by Bhimachar (1957) in *Lepidocephalichthys thermalis*.

Figures 12 and 13 are illustations of the hatchling and fry of *Mystus aor* collected from the nests in the spawning ground of Bhavanisagar.

### *Discussion.*

1. *Mystus aor* and *Mystus seenghala* are fishes of considerable commercial value. The biology of this fishery in artificial impoundments of rivers where they existed before as in Bhavanisagar and Mettur Dam is discussed in full.

2. The lacustrine condition is ideal for growth. They feed on copepods, rotifers, small fishes, insects, chironomids and fresh water oligochaetes.

3. Otolith and vertebrae are very useful indicators for assessing the age of this fish which is an annual breeder. The readings of the polymodel curve obtained by histogram studies of length frequency from the departmental catches were found to agree with the mean length obtained by vertebral and otolith age grouping. The range in length reached by the fish in the first year is 240 mm., second year 260–330, third year 340–400, fourth year 400–530, fifth year 520–630, sixth year 620–700 and seventh year 710–770 mm.

4. The mean weight reached by the fish each year is 100, 213, 229, 644, 1,392, 2,006 and 2,380 grams respectively. There is a gradual rate of increase in length in the first and second years, decrease in third year and then there is an increase up to fifth year after which there is a decrease. As regards weight there is an increase up to fifth year after which there is a decrease.

5. The relative condition is round about ·55 to ·68. The Kn factor decreases up to fourth year and onwards there is an increase.

6. The fishes are best caught in Rangoon net of mesh 4 to 4·5 cm. and also by Uduvalais. The catches are heavy during the pre-spawning season when they migrate upwards the top waters and post-spawning season in March, April when they start heavy feeding.

7. The breeding season is from February when they start upward migration and the nests are laid in the area just above the lacustrine area where the silt laden river flows lazily. The spawners are lethargic and this congregating stretch is the scene of heavy poaching. A conservation programme of patrolling this area from fishing and even from disturbance is necessary.

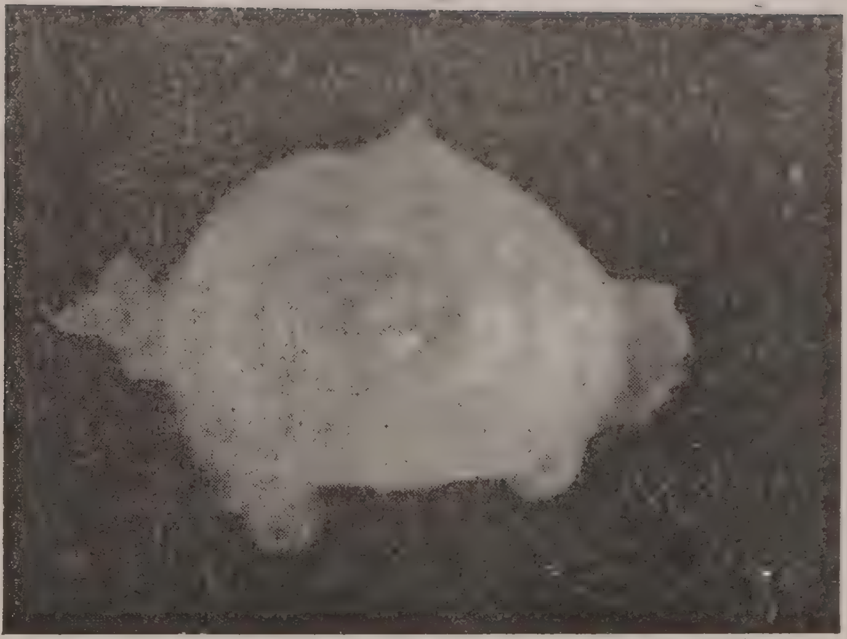
8. The record of landings at Bhavanisagar shows there is no adverse effect on the carps. *Mystus aor* will be a successful and repopulating fishery only in impoundments where there are no barriers, and at all fluctutations of level provided the river and lacustrine portion is continuous. The reason for the success of the fishery in Bhavanisagar, is due to the Moyar ideally suited for migration and construction of nest. In Mettur Dam, however, in normal years of level there are no chances of the pits being constructed up to Pannavadi at full reservoir level and the chances of nest when the reservior level is 45′ to 60′ during March to April is limited. There is absolutely no chance of *Mystus aor* breeders tackling the Hogainakal falls in the summer when the falls is high. The fish is recommended for stocking based on Bhavanisagar reservior studies for systems like Vaigai where during March to May, the river and the lacustrine conditions are continuous.

9. The presence of external gills in the hatchling of 8 to 9 mm. is a case of adaptation noted for the first time in this genus.

### *Acknowledgment.*

The authors wish to express their thanks to late Sri Raghbir Singh, I.A.S., Director of Fisheries, for assistance

PHOTO 1.
VERTEBRA SECTION OF MYSTUS AOR SHOWING
TWO AGE RINGS.



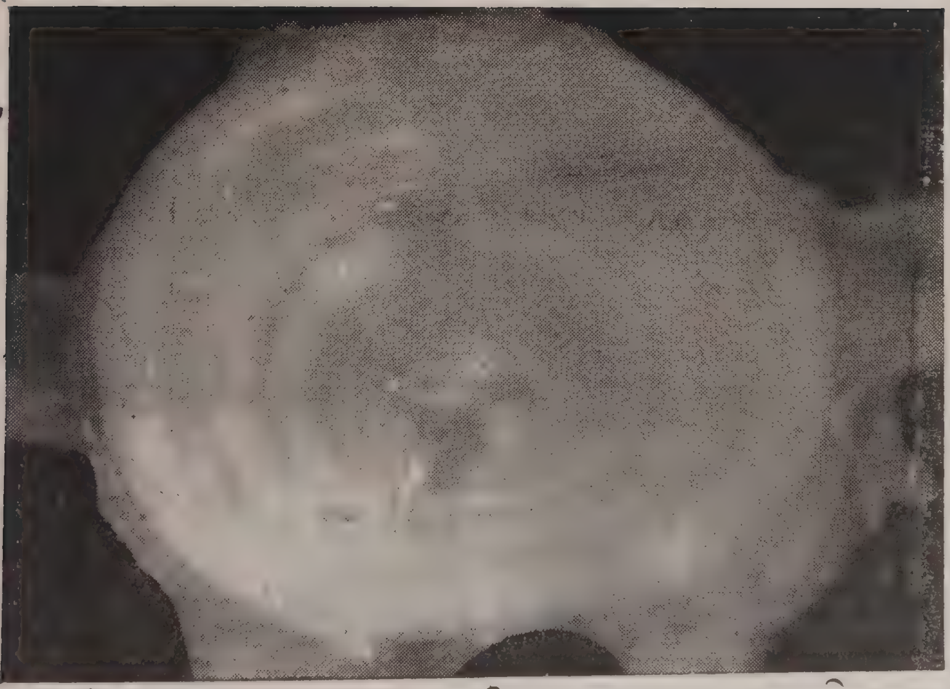


PHOTO 2.
VERTEBRA SECTION OF MYSTUS AOR SHOWING
THREE AGE RINGS.

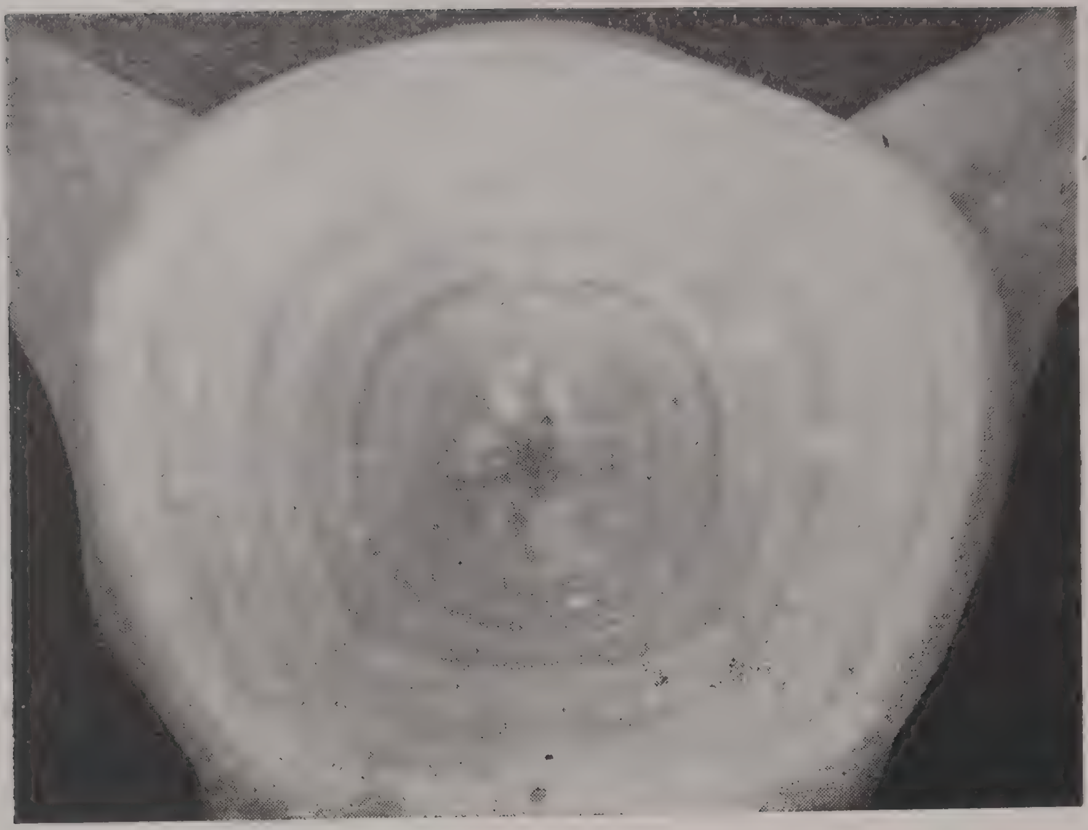


PHOTO 3.

VERTEBRA SECTION OF MYSTUS AOR SHOWING SIX AGE RINGS.

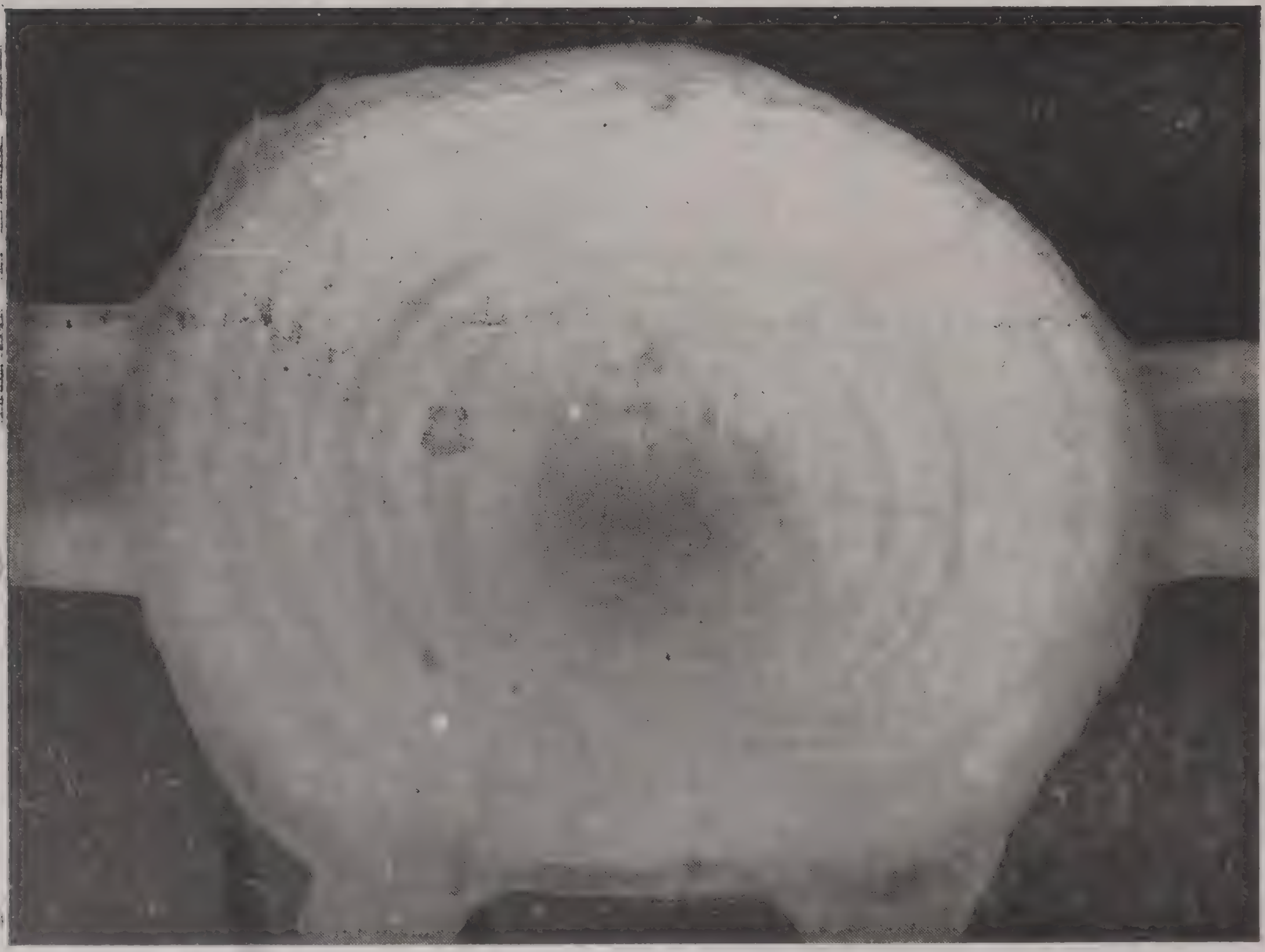
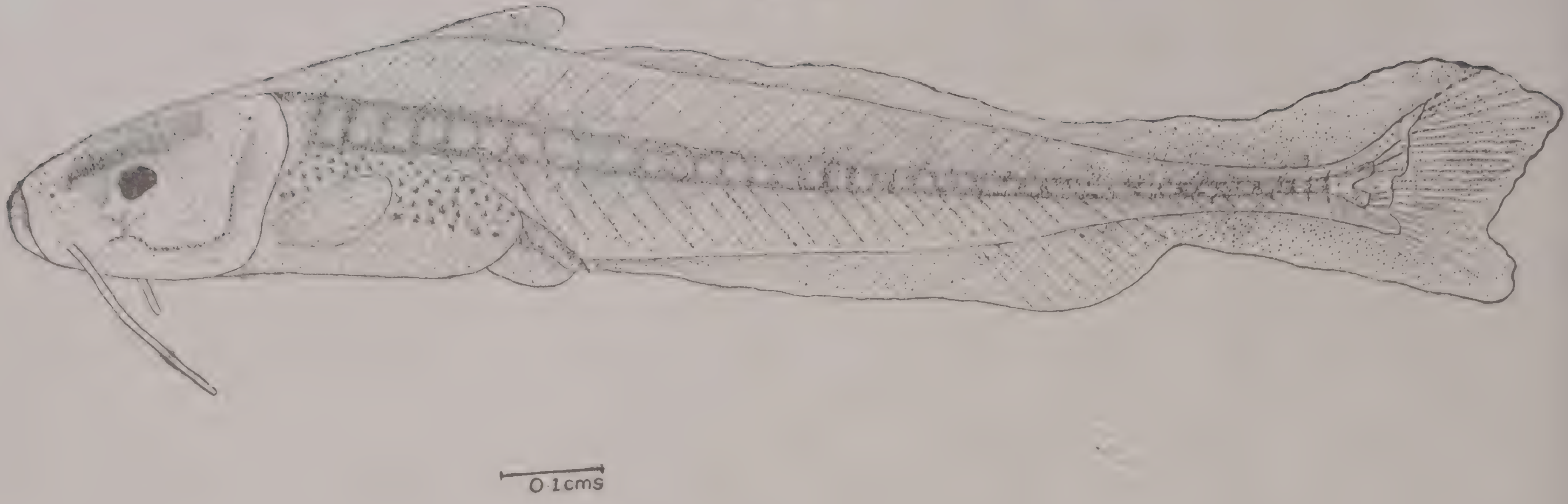


PHOTO 4.

VERTEBRA SECTION OF MYSTUS AOR SHOWING SEVEN AGE RINGS.

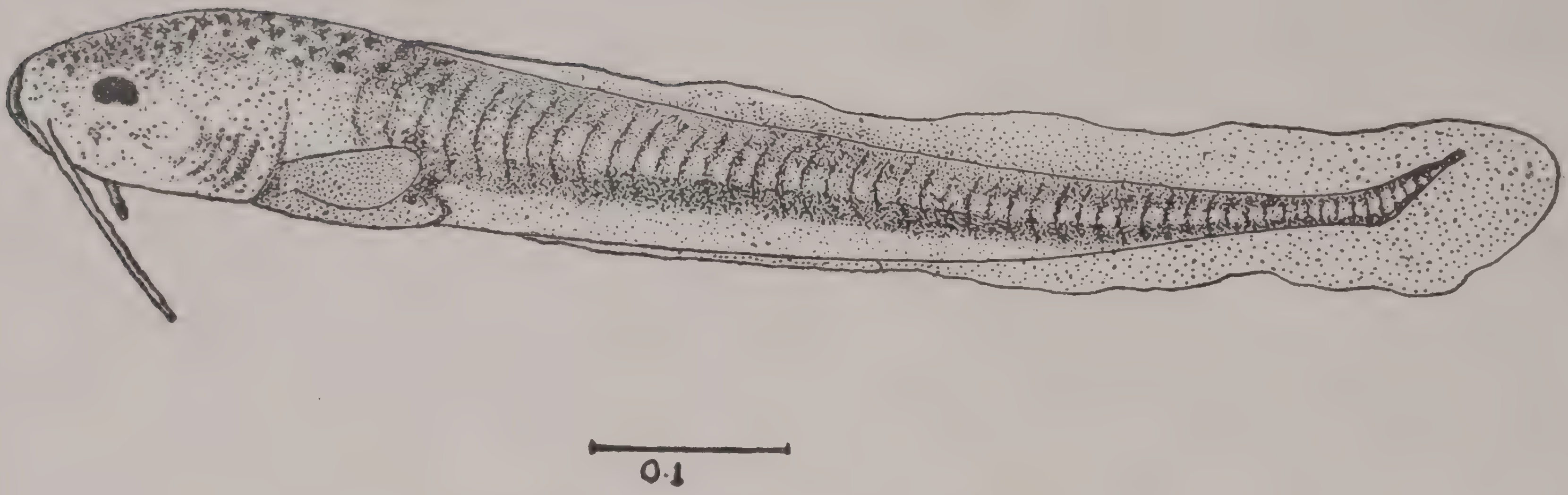
PHOTO 5.
DIFFERENT AGE GROUPS OF MYSTUS AOR CAUGHT IN THE RANGOON NETS IN BHAVANISAGAR RESERVOIR.

Fig. 13



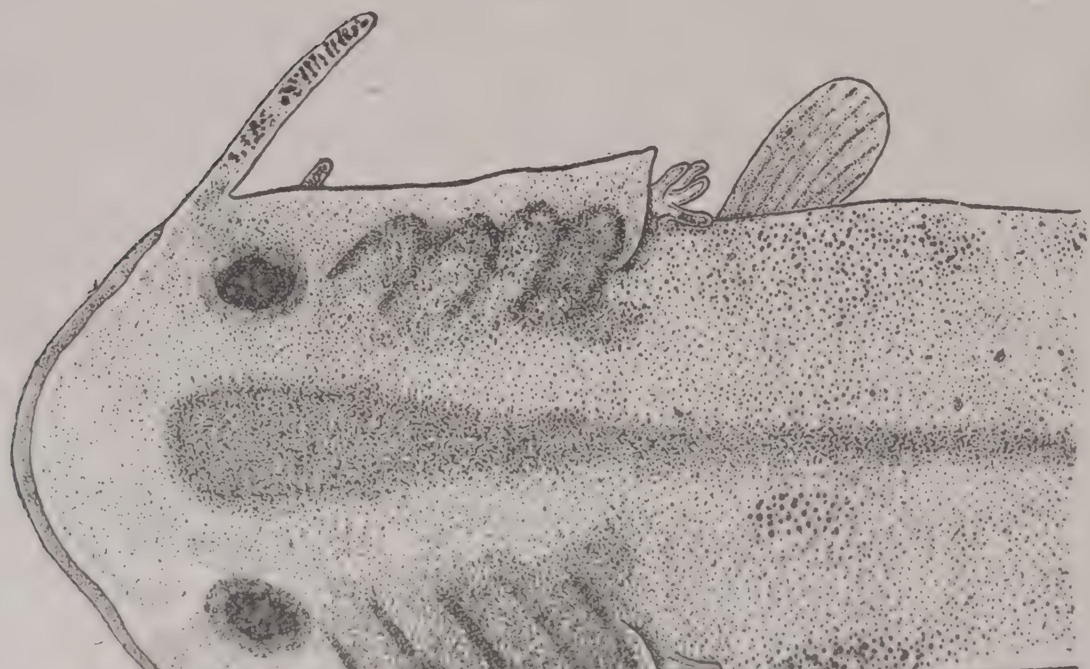
MYSTUS AOR FRY 1·4 cms. LONG.

Fig. 12



MYSTUS AOR HATCHLING 0.8 cms. LONG.

Fig. 11



HEAD REGION OF MYSTUS AOR SHOWING EXTERNAL GILLS.

rendered during the work, to Sri N. V. Choodamani and P. I. Chacko, Deputy Directors of Fisheries, for suggestions during the course of the work and Sri A. Srinivasan, Assistant Director of Fisheries (Hydrology) for the hydrological data of the spawning bed and Sri E. R. Venkatasamy, Inspector of Fisheries, for diving and collecting the spawn of cat-fish in the Moyar side.

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# ON THE OCCURRENCE OF A NEW SPECIES OF ICHTHYOPHTHIRIUS (CILIATA) IN THE FRY STAGE MURREL, OPHIOCEPHALUS MARULIUS (HAM)

BY

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While studying the large scale mortality of the "red stage" murrel fry, white spots of varying sizes were observed on the skin and fins of all the fish reared in cement cisterns. The spots were identified as tiny eruptions enclosing an enchelid (order Holotricha) ciliate parasite of the genus *Ichthyophthirius sp. Nov.* (Figs. 3A and B).

*Ichthyophthirius multifilis Fouquet*, the only species known up till now according to Buschkiel (reported by M. Sachlan, 1952), was discovered in Europe in 1869 [M. Sachlan (1952)]. Dr. A. L. Buschkiel, a Dutch Hydrobiologist, after a thorough study on *Ichthyophthirius*, both in Europe and East Indies, mentions an epidemic in fish ponds in the isle of Java, causing extensive losses [Van Duijn Jnr. (1956)]. The first report of this disease in India is by Y. R. Tripathi in 1955 on the young *Xhiphophorus hellerii*.

In *Ichthyophthirius multifilis Fouquet* the specific name 'multifilis' indicates its *prolificness* due to multiple fission forming 500 to 1,200 individuals within a cyst. [Sachlan (1952)]. Observations by the authors, on hundreds of this ciliate now described, during day and night, revealed that they divided only by simple direct fission. No cyst was formed. On account of this reproductive behaviour and the lateral position of the cytostome, not terminal, as in *Ichthyophthirius multifilis Fouquet*, it is felt, that it well deserves a distinct specific status.

## MORPHOLOGY AND BIOLOGY

The tiny eruptions enclosing the parasites are made of one or more layers of the host epithelium augmented by the epidermis due to the irritation caused by the parasite. These eruptions are 0·3 to 0·7 mm. in diameter while the parasites alone vary from 0·25 to 0·5 mm. in diameter. In some cases two lesions were found fused to form one. The smallest of the eruptions just protruding out of the cutis are 0·1 mm. in diameter. Compared to other areas, those on the eye are very big 1·25 to 2 mm. in diameter, the morbid growth of the epithelial wall itself measuring 0·50 to 0·75 mm. But for the extreme morbid growth in the eye region, parasites of sizes 1·0 mm. [Van Duijn Jnr. 1956] and 2·5 mm. diameter [M. Sachlan, 1952] did not occur.

The mature parasite just emerging out of the host is nearly spherical, but it changes its shape (amoeboid) to a great extent especially in an unsuitable medium (e.g.) a 2 ppm. solution of methylene blue. It becomes slightly elongated when it gets anchored to a substratum.

The body is covered with cilia of uniform size (Fig. 1). The metachronous beat of the cilia presents a picture of a wave passing along the margin successively. While in the host inside the lesion, it performs lively rotating movement but for which one would be led to presume that the lesion is a cyst formed by the parasite. The mature parasite while free in water progresses by successive rotating movement. Sometimes instantaneous alteration of form is brought about by the rapid contraction of the myonemes.

The circular mouth is lateral in position almost in between the anterior and posterior ends of the cell, thus differing from *Ichthyophthirius multifilis Fouquet* where the position is terminal. The cytopharynx is recognized by the presence of elongated rods. Dark bodies are seen in the cell which are probably the ingested cells of host.

The adult is mononucleate possessing only a horse-shoe shaped macronucules, a feature common to the genus. During division the micronucleus makes its appearance as a brown spot on the macronucleus somewhat excentric in position.

Multiplication is by simple direct fission (Fig. 2A). Van Duijn Jnr. (1956) reports that simple division occurs in *Ichthyophthirius multifilis Fouquet* only when the oxygen content of the medium is remarkably reduced. However mention is not made of the concentration of oxygen at which simple direct fission is resorted to. Oxygen content during the present study never went down below 6·0 mg/L. Nevertheless in no case cyst formation occurred.

The maicronucleus divides first and the two halves become spherical. The micronucleii are discerned as brown spots on the macronucleii. During the process a darkly pigmented granular zone develops around the nucleii (Fig. 2C). Each cytoplasmic half twists over the other in opposite directions along the plane of division which deepens the constriction of the cuticle. In the last phase only a narrow bridge exists in between, which extends to more than 400 microns because of the pull exerted by the dividing halves from the opposite directions (Fig. 2B). In some cases, instead of this twisting and pulling, only the cilia of the two halves beat in opposite directions right from the plane of division which seems to exert the necessary force required for constricting the cuticle. This process lasts for more than thirty minutes. The optimum temperature for division is 74° F. which prevailed in the nights during the study and the range is 72 to 78°F. The ultimate number of individuals formed is not more than eight. During the first one or two divisions equal halves are formed and later on slightly unequal halves are produced.

These individuals are then after a host, and have been found to attach themselves to debris coming on the way. In aquarium jars the young parasites have been found to anchor themselves to the fins of the young fish when they remain static. Quite often the fish is found to react to this infection by flapping the particular portion uneasily as if disturbed. When it succeeds to attach itself, aided by the host slime, it bores its way into the skin where it is said to feed on the dead epithelial cells [Van Duijn Jnr. (1956)].

When it grows in size the tiny bladder enclosing the parasite erupts out as a white spot on the surface of the skin. On 24th December 1963 a murrel fry having six white spots was kept in a 4 ppm. methylene blue solution to avoid reinfection. On 26th December 1963, the fish had thirty-three spots and the number did not increase since then. It appears therefore after three or four days the fish contracted the infection, almost all lesions erupt out. The exact time between the appearance of the spots and the leaving of the parasite is not constant. On 26th December 1963, a lesion appeared on the right eye of a fry which already had thirty-two eruptions. On 28th December 1963, the parasite from the eye had left the host but others remained. On 23rd December 1963, a fry of 45 mm. size had only one spot on the dorsal aspect of the head. On 27th December 1963, besides the spot on the head, two on the left flank of the body, two on the right pectoral fin and one on the left pectoral fin were found. On 28th December 1963 all have left but one newly appeared at the junction of the dorsal fin with the body. So it is found that most of the parasites leave after 3 to 7 days of the appearance of the spots when the temperature is between 72° F to 78° F. But they may take longer time to leave when conditions are unfavourable.

## COMBINED INFECTION WITH GYRODACTYLUS

All the fish of size 25 mm. and below already infected with *Ichthyophthirius*, contracted a secondary infection with *Gyrodactylus*. They were found swarming in large numbers *all over the body* more specially on the fins. According to M. Sachlan such a multiple infection of *Ichthyophthirius* together with *skin flukes* is common in Europe but seldom found in Indonesia.

## SYMPTOMS OF INFECTION

Advanced infection brings about loss of equilibrium and exophthalmia ; the fish lies on its side or back and performs unhealthy movement. It whirls around aimlessly when disturbed and prefers taking shelter among weeds. The pectoral and dorsal fins droop down. The respiratory movement of the operculum is reduced to about half that of a healthy fish of the same size. The movement fluctuates from 57 to 68 times per minute whereas that of an uninfected fish is 115 times per minute. Quite frequently the fish rises to the top and gulps air, sometimes twists within five minutes and occasionally a gas bubble is sent out through the mouth. The fins and body shiver violently while dying.

## TREATMENT

Van Duijn Jnr. (1956) and H.S. Davis (1946) are of opinion that since this parasite is surrounded by the living host tissue where it cannot be penetrated by chemicals it is very difficult to combat the infection ; but however the knowledge of its life-cycle has been useful to evolve measures to destroy the parasites leaving the host for multiplication. Van Duijn Jnr. who has tried quinine salts, mepacrine ydrochloride, mercurochrome and medical quality methylene blue, claims that methylene blue is the most effective in killing the parasite free in water. He used methylene blue as a permanent bath of 1 : 500,000 and at temperature between 70°F to 80°F found the disease disappearing in five days. Experiments conducted in enamel bowls on infected fish with methylene blue and observations on the behaviour of the parasite to a drop of methylene blue in microscopic slides confirm Van Duijn's claim. However, experiments conducted in open cement cisterns did not give favourable results with methylene blue.

*Methylene blue.*—*Ichthyophthirius* reacted to methylene blue of 2 ppm. concentraction by altering its shape frequently by the formation of amoeboid processes. Sometimes into a small bud of about one-eighth the size of the body the rest of the cytoplasm streamed in. This process was followed by an elongation of the body and fast aimless movement different from the slow circular movement of the mature parasite free in water. Occasionally from one end of the elongated cell a spherical bud was put forth which pinched off while the mother half rotated vigorously around its own axis (Fig. 4A). According to Van Duijn Jnr. (1956) budding is a means to get rid of the portions penetrated by methylene blue. At last the cuticle ruptured and the cytoplasm exuded out (Fig. 4B). The macronucleus either disintegrated or elongated much while the ends broke off.

An infected young murrel of 45 mm. size having six white spots was introduced on 24th December 1963 in an enamel bowl containing 4 ppm. methylene blue solution. On 26th December 1963, thirty-three white spots were counted and on 27th December 1963 only fourteen spots remained. No reinfection was noted.

TABLE I.

*Showing percentage of mortality during Methylene blue treatment in three cement cisterns.*

| *Date.* | *Stock.* | | | *Number died.* | | | *Percentage of mortality.* | | | *Food.* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Cistern 1.* | *Cistern 2.* | *Cistern 3.* | *C1.* | *C2.* | *C3.* | *C1.* | *C2.* | *C3.* | *C1.* | *C2.* | *C3.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 17th January 1964 .. | 250 | 250 | 250 | 16 | 23 | 43 | 6·4 | 9·2 | 17·2 | Fish pellets. | 100 numbers of 11 mm. size Tilapia,<br>200 numbers of 21 mm. size Tilapia,<br>200 numbers of 28 mm. size Chela. | Plankton rich in copepods. |
| 18th January 1964 .. | 234 | 227 | 207 | 25 | 36 | 39 | 10·1 | 16 | 18·8 | Do. | Nothing was added afresh. | Do. |
| No feeding was done on 19th January 1964. | | | | | | | | | | | | |
| 20th January 1964 .. | 209 | 181 | 168 | 120 | 115 | 97 | 57·4 | 63·5 | 58 | Do. | 5C numbers of 11 mm. size Tilapia. | Do. |
| 21st January 1964 .. | 89 | 66 | 71 | 13 | 19 | 15 | 14·6 | 28·7 | 21 | Do. | Nothing was added afresh. | Do. |
| 22nd January 1964 .. | 76 | 47 | 56 | 9 | 15 | 25 | 11·8 | 31·9 | 41 | Do. | Do. | Do. |
| Total mortality for 250 | 183 | 213 | 219. | | | | | | | | | |
| Percentage of mortality for 250. | | | | | | | 73·2 | 85·2 | 87·6. | | | |

However, Table 1 shows that methylene blue of 4 ppm. loses its effect when treated in open cement cisterns (4′ × 3′ × 2′) and the young fish succumbed in large numbers. Following the second day of administration the colour of methylene blue began to fade. Van Duijn Jnr. (1956) opines that methylene blue may lose its quality by oxidation and by absorption by decaying organic matter. The high mortality which occurred in the three cisterns may be explained by one or other of these factors. All three cisterns were planted with *Elodea* and *Hydrilla* for shade, the dead leaves of which might have added to the putrifying organic matter. In cistern two and three, the presence of excreta of the forage and the dead plankton respectively might have been responsible.

## HOMOTROPINE HYDROBROMIDE AND COPPER SULPHATE.

H. S. Davis (1946) reports that according to Ellis (1937) salts of heavy metals like copper combine with the mucous of the skin and gills forming an insoluble compound which brings about asphyxiation. It was observed in the present study that the transparent mucous became white in contact with copper sulphate. H. S. Davis (1946) used sodium chloride to remove the slime before treatment with copper sulphate. We have tried homotropine hydrobromide in different concentrations for varying periods and found that, besides being not toxic for a day or two up to 50 ppm. concentration, the slimy mucous from the skin of the fish was completely removed within 6 to 10 hours. After this preliminary treatment the infected fish were transferred to a 1 to 2,000 solution of copper sulphate. It is found that the time that could be allowed for a fish of 24 mm. size and below in copper sulphate without injurious effect is only 90 seconds and that for 45 mm. size and below 180 seconds. By the removal of the slime all the spots were exposed to the direct action of copper sulphate; the eruptions were found ruptured and the parasites killed; whereas methylene blue killed the parasite by disintegrating the cell, copper sulphate killed by fixing it. After this treatment the fish were kept in running or oxygenated water.

When the fish were kept for 5 to 6 minutes in copper sulphate solution they suffered mortality at a high rate. Four hundred fry stage murrels of 25 mm. size, when kept in 1 to 2,000 copper sulphate solution for six minutes, came to the surface gulping air without an exception. Though they were transferred to flowing oxygenated water, the whole lot died out within three days.

*Host-parasite relationship.—Ichthyophthirius* readily takes to a wide range of hosts. H. S. Davis (1946) reports that trouts of all ages are infected when *Ichthyophthirius* becomes established in trout hatcheries. But mostly it is not injurious because the parasite develops slowly at low temperatures and is unable to complete its life-cycle where there is rapid flow of water. Severe epidemics are common in Western Europe (Van Duijn). In Indonesia *Puntius javanicus* (Blkr), *Helostoma temmincki* C.V. and *Osphronemus goramy Lac* were commonly attacked (M. Sachlan) Y. R. Tripathi (1955) found, *Labeo bata* (8 c.m.) and *Cirrhina mrigala* (8 c.m. and8·5 c.m.) susceptible to infection by *Ichthyophthirius*. We have artificially infected *Labeo fimbriatus* (6·5 c.m.) and *Barbus hexagonolepis* (6 c.m.) and since the fifth day their condition became highly insabularious. *Labeo fimbriatus* (15 c.m. to 25 c.m.) were not affected. *Lepidocephalichthys thermalis* and *Chela malabaricus* were readily susceptible and succumbed largely. *Tilapia mossambica* (3 c.m. and 5 c.m.) were not infected. Infection of fish belonging to family Ophiocephalidae is recorded for the first time. Young murrels of three different size groups kept in aquarium jar for the same period reveal that the fry stage is the most susceptible for *Ichthyophthirius* as well as for a multiple infection with *Gyrodactylus* (Figure 5). Table II depicts the intensity of infection among the three size groups.

TABLE II.

*Showing the intensity of infection among different size groups of murrel.*

| *Size groups.* | *Total length.* | *Weight.* | *White spots.* | *Gyrodactylus.* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| | | GM. | | |
| Size I | 25 mm. | 0·112 | 331 | 1000s |
| | 25 mm. | 0·112 | 420 | 1000s |
| Size II | 32 mm. | 0·227 | 102 | Nil. |
| Size III | 55 mm. | 0·290 | 33 | Nil. |

Fingerling murrels (7·5 c.m. to 9·5 c.m.) were never infected even under artificial conditions.

## SUMMARY

1. A new species of *Ichthyophthirius* a ciliate parasite on the fry stage murrel *Ophiocephalus marulius* is recorded for the first time.

2. Mode of reproduction is by simple direct fission. Position of cytostome is lateral. In these two points it differs from *Ichthyophirius multiafilis Fouquet*, the only species so far described.

3. Combined infection with Gyrodactylus occurs in murrels below 25 mm. size.

4. The new species is named *Ichthyophthirius-simplifilis* because of the simple fission in breeding.

5. Observations on the behaviour of this parasite to methylene blue confirms the claim of Van Duijn Jnr.(1956) that it is the most effective measure to combat this parasite in the laboratory. But experiments conducted in open cement cisterns did not give favourable results.

6. Fifty ppm. homotropine hydrobromide solution removes the slime from the skin thus exposing the lesions for the direct action of copper sulphate and preventing the formation of compounds with mucous which brings about asphyxiation.

7. Intensity of infection is greater in fry stage murrels than in fingerlings.

8. *Labeo fimbriatus* (6·5 c.m.) *Barbus hexagonolepis* (6·0 c.m.) *Lepidocephalichthys thermalis* and *Chela malabaricus* were artificially infected.

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Fig. 1

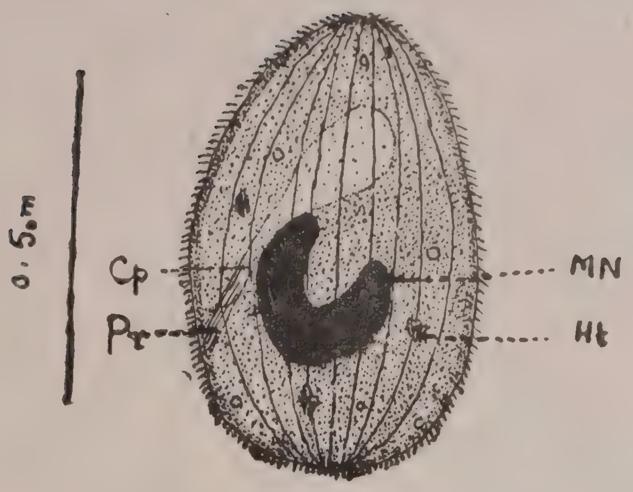


Fig. 2-a

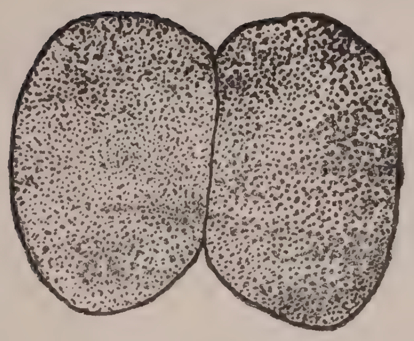


Fig. 2-b

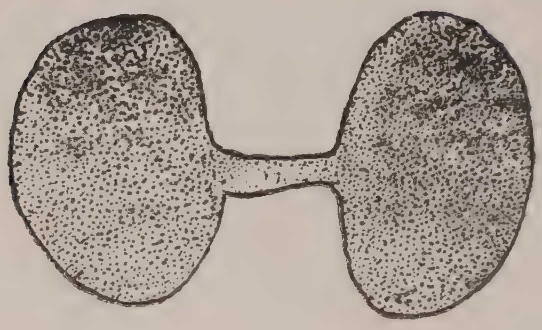


Fig. 2-c

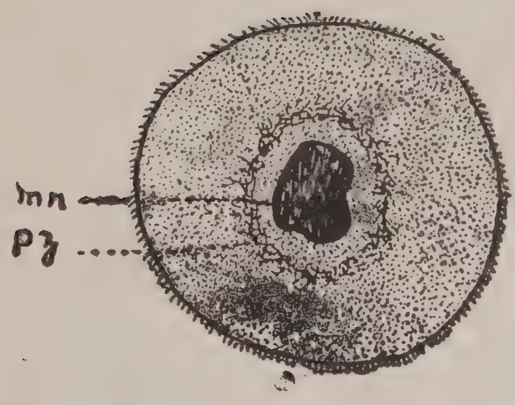


Fig. 1.—MATURE ICHTHYOPHTHIRIUS Sp.

Fig. 2-a.—SIMPLE DIVISION OF ICHTHYOPHTHIRIUS Sp.

Fig. 2-b.—ELONGATION OF THE CYTOPLASMIC BRIDGE.

Fig. 2-c.—SHOWING THE MICRONUCLEUS ON THE MACRONUCLEUS AND THE PIGMENTED ZONE AROUND THE NUCLEII.

KEY TO LETTERING.

Cp.—CYTOPHARYNX.

He.—HOST EPITHELIUM.

Ht.—INJESTED HOST TISSUE.

I.—ICHTHYOPHTHIRIUS IN TISSUE ERUPTION.

MA.—MACRONUCLEUS.

Mn.—MICRONUCLEUS.

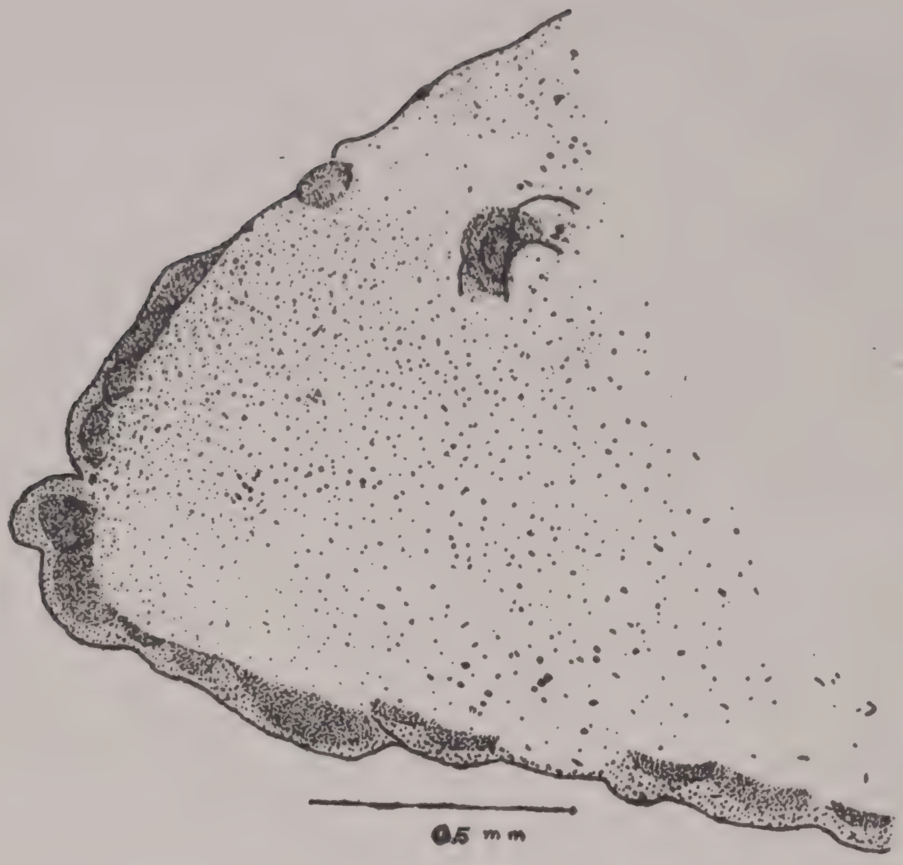
Op.—OPERCULUM.

Pf.—PECTORAL FIN.

Pr.—PHARYNGEAL RODS.

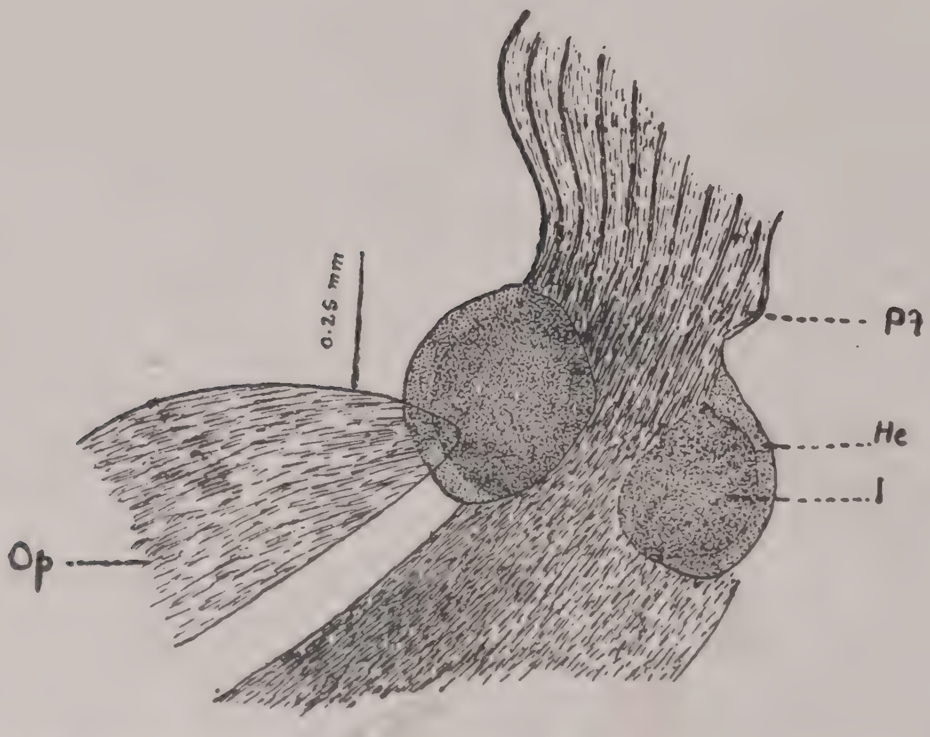
Pz.—PIGMENTED ZONE.

**Fig. 3-a**



SHOWING ERUPTIONS ON THE HEAD AND EYE.

**Fig. 3-b**



ERUPTIONS AT THE ORIGIN OF THE PECTORAL FIN.

Fig. 4-a

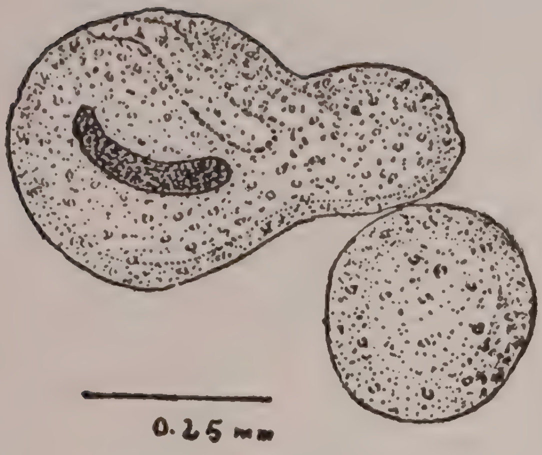


Fig. 4-b

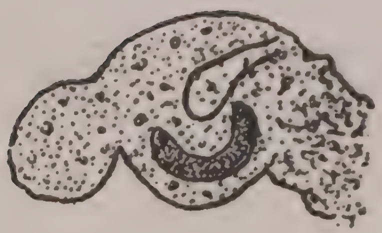


Fig. 5-a

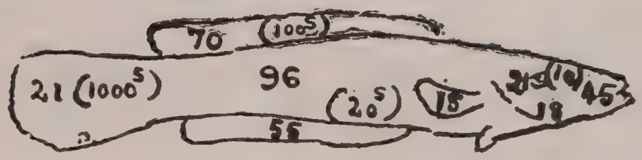


Fig. 5-b

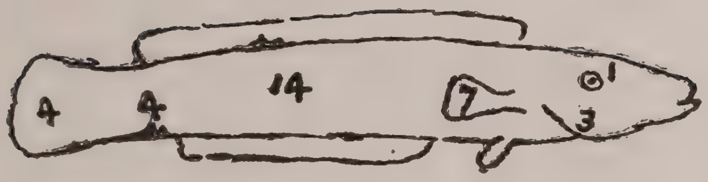
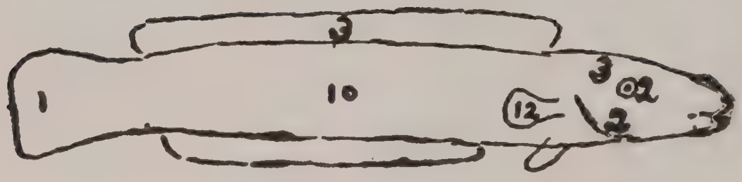


Fig. 5-c



F g. 4-a.—BUDDING IN METHYLENE BLUE.

Fig. 4-b.—DISINTEGRATION IN METHYLENE BLUE.

Fig 5-a, b, c.—SHOWING THE RELATIONSHIP BETWEEN THE SIZE OF THE FISH AND THE INTENSITY OF INFECTION.

| | *Total length of the Fish.* | *Weight of the Fish.* | *Number of Ichthyophthirius.* | *Number of Gyrodactylus.* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| a. | 24 mm. | 0·012 gm. | 331 | 1,000s. |
| b. | 45 mm. | 0·19 gm. | 33 | Nil. |
| c. | 55 mm. | 0·29 gm. | 33 | Nil. |

(Bracketed numbers indicate Gyrodactylus Unbracketed numbers indicate Ichthyophthirius.)

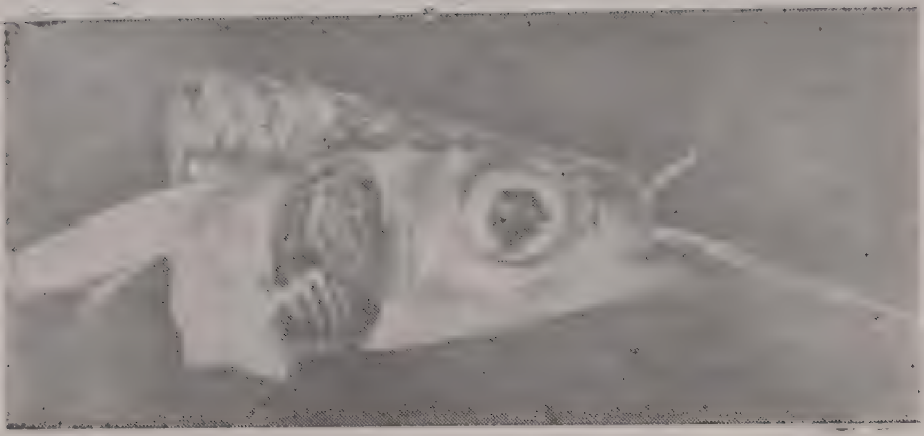


Photo 1—Female *Irona far* in the gills of *Hemirphanpus far* (Day) showing the anterior half of its body immersed within the gill tissue.

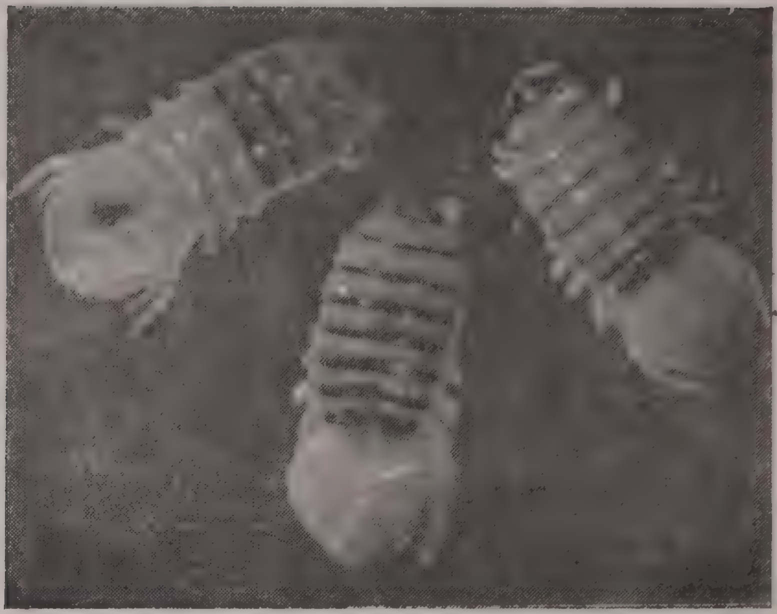


Photo 4—Three differently stripped males of *I. far*, one showing striations in the anterior thoracic segments only, the second in all, and the third in the few posterior segments only. Uropods longer than telson here.

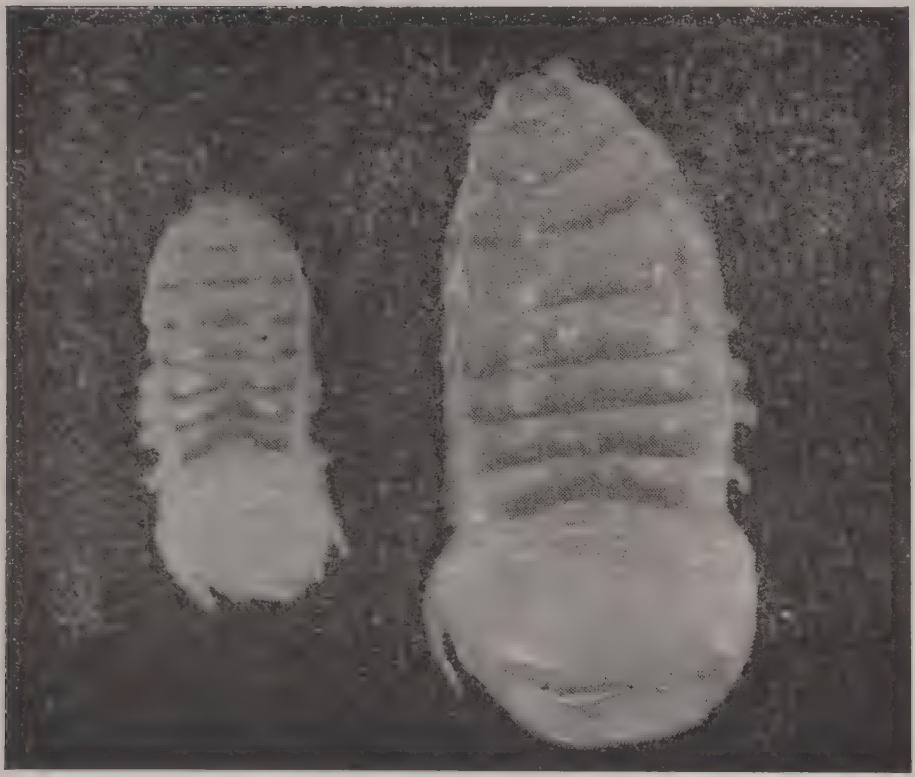


Photo 2—A pair of *Irona far* showing relative size, colour of telson, etc. In the female, the membraneous telson is broader than thorax.

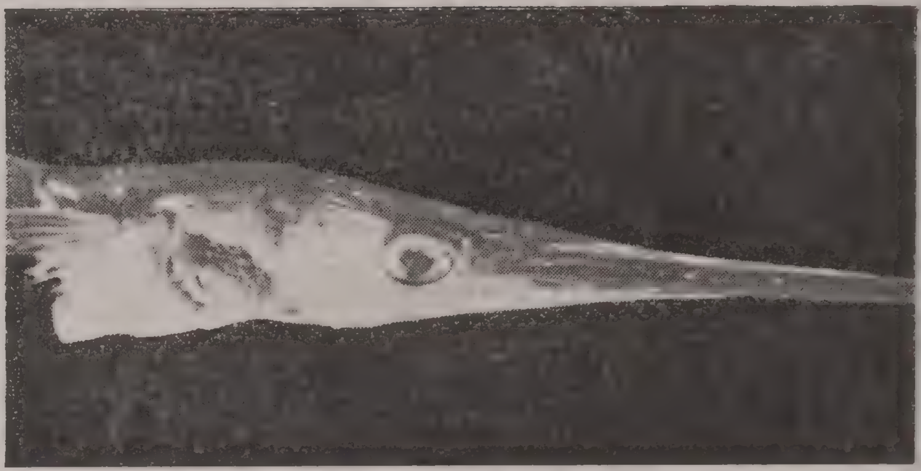


Photo 5—The parasite *I. gigantea n. sp.* with the host *Tylosurus lieurus* (Bleeker). It left half of the body is immersed in the gill tissue.

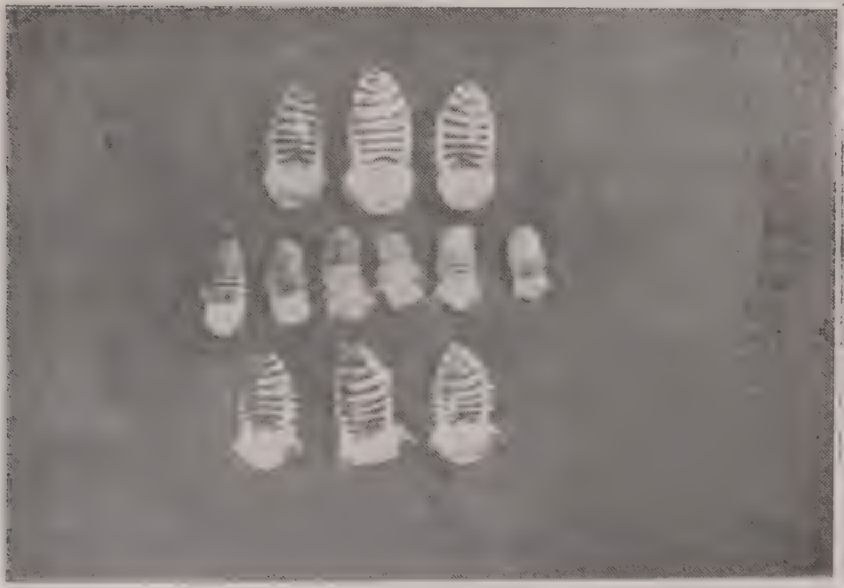


Photo 3—Photograph of six female and six male specimens of *I. far*. The middle row shows differently striated males.

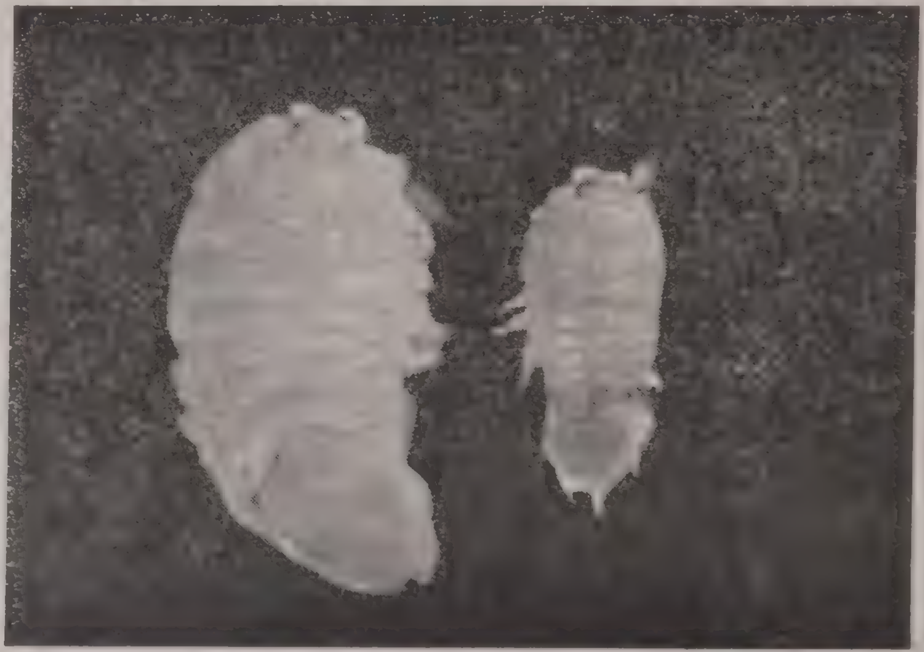


Photo 6—A pair of *Irona robusta* showing colouration, symmetary and relative size. The male is symmetrical with uropodes extending beyond the telson.

# ON A RE-DESCRIPTION OF TWO SPECIES OF IRONA, IRONA FAR AND I. ROBUSTA (NAIR 1650)

BY

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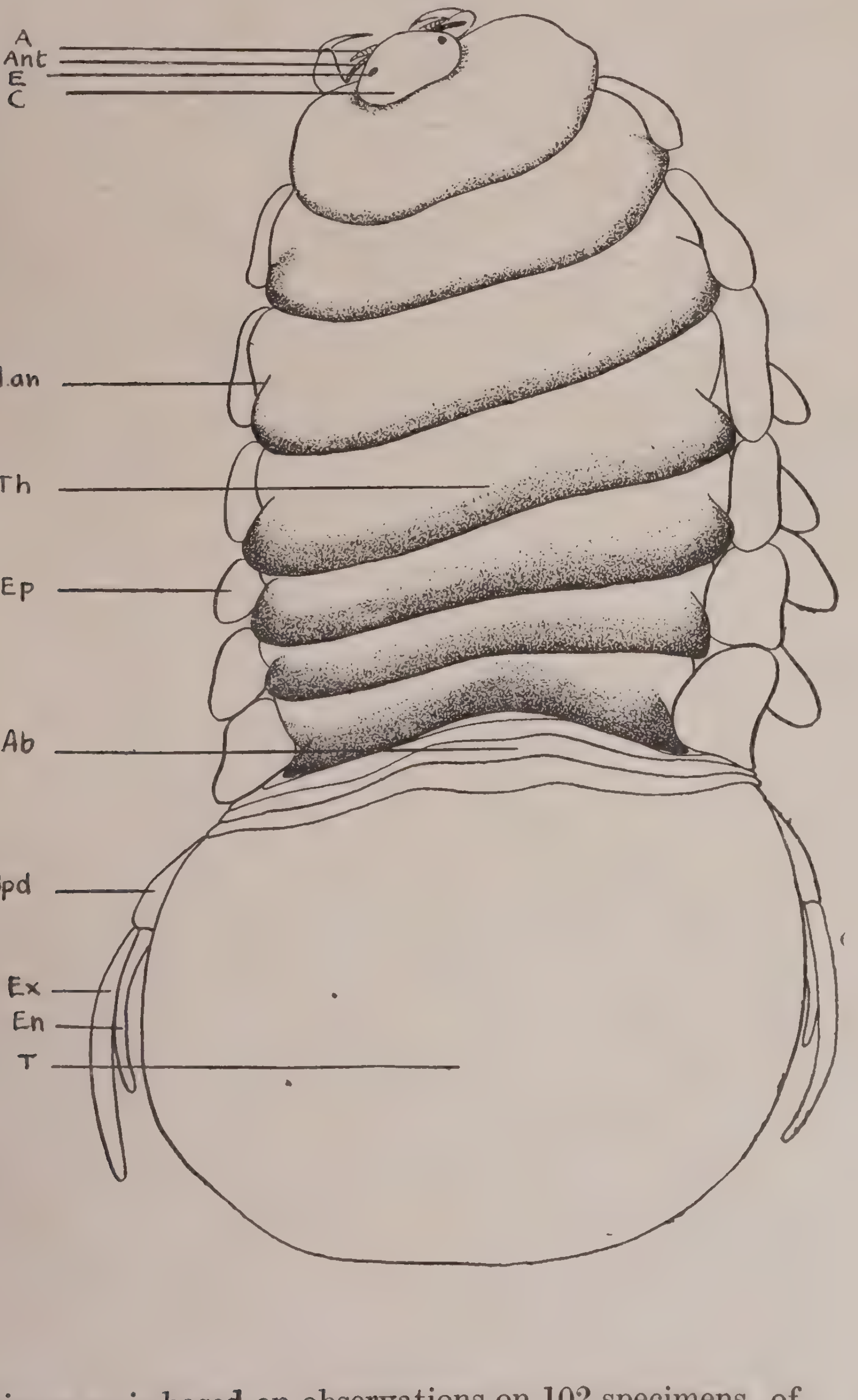
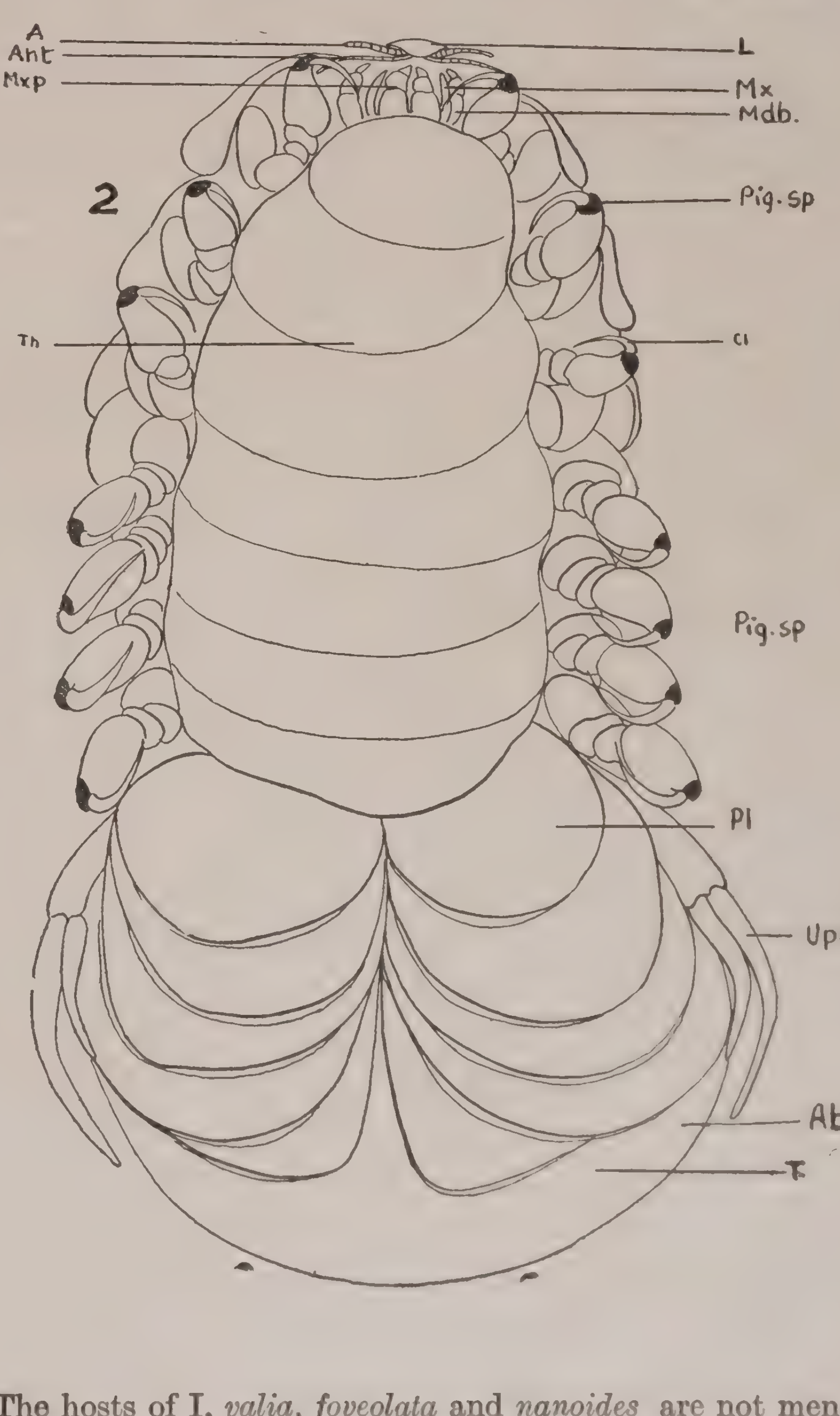
## INTRODUCTION

While engaged in collection and study of cymothoan parasites of fishes from Madras Coast between November 1947 and January 1950 these parasites were collected in large numbers from Madras fishes and studied. The work was done in the University Zoological Research Laboratory, Madras, while serving as Research Assistant.

Unfortunately while the paper was about to be published in 1950 a paper on these parasites was published by S. G. Nair (1950) in the Madras University Journal. As his description was found to be erroneous in many details of importance and as the description of males and their appendages was very meagre, a re-description of these species has been found necessary.





This paper is based on observations on 102 specimens of *I. far* and 90 specimens of *I. robusta*. Appendages of atleast a dozen specimens of females and males from each species have been dissected and studied.

A key to all the known species of *Irona* is also furnished in addition to an exhaustive account of these parasites.

The distribution of *Irona* species seems universal. *I. melanosticta* has been recorded from Sandwich Islands [Sch. and Meinert (1884)] Japan [Thielemann (1910)], S. Africa [Bernard (1914)] and S. Australia [Hale (1926)] and is said to infest *Tylosurus chorum* and *Hyporhamphus intermedius*. *I.rendardi* (Bleeker) is said to occur in South Australia and infests *Tylosurus ferox*, *T. macleayana* and other *T. species*. *I. nana* [Sch. and Meinert (1884)] occurs in America in *Hemiramphus* species. *I. foveol* [Hansen (1897)] also occurs in America but the host is unknown. *I. nanoides* [Stebbing (1905)] occurs in Ceylon waters.

The hosts of I. *valia*, *foveolata* and *nanoides* are not mentioned by the authors. *I. far* and *I. robusta* infest the branchial chamber of *Hemiramphus far* and *Tylosurus lieurus* and are recorded from Madras coast.

## 1 IRONA FAR

One hundred and two parasites (Photo 1-4) were collected from nearly 125 specimens of *Hemiramphus far* caught on the Madras coast during July, August and September 1948 of which 27 were males. The females (Photo 1) are much larger than the males and always found in the branchial cavity of the host. Usually the anterior region of this parasite is immersed and hidden in the tissues of the gills of the host while the posterior region with telson and uropods only are exposed external to the gill flap. The males (Photo 2-4) are found attached to the soft skin of the body, very often near the base of caudal or dorsal fins. One or two of these males were collected from the branchial cavity also. When disturbed these parasites often leave the host and crawl to the other fishes drawn in the net. This habit has been observed by Dr. Linton in *Irona nana*. Males and young females of these parasites were found to live up to 25 days under laboratory conditions outside the host fish.

*The females* (Figures 1 and 2)—*Size and colour.*—The size varies from 18×7 mms. to 26×11 mms. A female of average size 22×9 mms. has been described below :—

| | L. B. |
|---|---|
| Head .. .. | 1·5×2 mms. |
| Thorax .. .. | 14×9 mms. |
| Abdomen excluding telson. | 1·75×9 mms. |
| Telson .. .. | 6×10 mms. |

*Colour.*—Yellow with segmental black stripes. Epimera and telson—white. Bases and tips of dactyli dark brown.

The characteristic feature of this parasite (Figure 1) is its colouration. It has a dark yellowish dorsal ground colour with prominent dark brown or black transverse bands across the posterior margins of the segments. The first thoracic segment unlike the others shows this pigmental stripe at its anterior concave margin also. Those of the last three thoracic segments are wider, darker and hence more conspicuous than the anterior stripes. The abdominal stripes are very delicate and less conspicuous. The epimera are either white or yellowish while the well developed broad telson is always white. In some forms very minute pigmented cells lie scattered over the dorsal surface of the body specially in the cephalon and segments of the antennal pairs. The tips of all the dactili are dark brown in colour. The bases of the dactili externally at their junction with the propodi, show circular or triangular dark brown areas (Figure 2). To my knowledge such pigmented areas or dots have not been described in any other cymothoan.

*General appearance.*—The body is more or less, oval and broad, moderately convex very much twisted either to the right or to the left and is about 2½ times as long as wide. The *cephalon* is very small about 1/14th of the length roughly triangular and is deeply set in the anterior margin of the first thoracic segment. It is broader than long and its broad front is curved and folded ventralwards over the bases of the antennal pairs. The eyes are small, circular about 0·75 mms. in diameter and are located in the mid-lateral margins of the cephalon.

In very large specimens the eyes seem to be covered up by the thin integument but in most they appear to function. The *thorax* constitutes the major length of the body and forms two-thirds the total length of the specimen. The broadest region is that of fourth and fifth segments. The antero-lateral angles of the first thoracic segments are short, curve round the posterior margin of the cephalon and extend forwards up to the posterior margin of the eyes. This segment is longer than the three succeeding segments and has a concave posterior margin. The second, third and fourth segments are slightly shorter than the first but longer than the last three segments. The posterior margin of the last thoracic segment is deeply concave, and covers the anterior abdominal segments partially. The *epimera* (Figure 1) of all the thoracic segments but the first are very distinct. Those of the second and third are much narrower while those of the last four are oval, larger and broader. Those of second to fifth segments do not reach the posterior margins of the segments while those of sixth and seventh nearly reach. In a few specimens these epimeral plates just touch each other or gently overlap each other posteriorly. They are not directed outwards and dorsalwards as in *I. nanoides* and *I. foveolata* but are flat, oval and do not rise above the level of the body surface.

The antero-lateral angles of third to seventh segments are distinctly marked off by oblique lines while those of the first and second segments are not clear. The peraeopods are shorter in proportion to the size of the body than in males, and increase in length very gradually. In some the last three peraeopods of one side are closely set and seem to be shorter than the anterior pairs. This is only because of the twisted nature of the body. Measurements show that these are really slightly longer than the anterior pairs. There are no carina at the basis of the posterior peraeopods.

The *abdomen* is not narrower than the thorax and is continuous with it. The exposed abdominal region excluding the telson is either as long as or slightly longer than the last thoracic segment. The first segment is completely hidden by the last thoracic segment while the second is partially hidden laterally. The third, fourth and fifth segments are very distinct of which the last is slightly longer than the preceding ones.

The telson is nearly 1½ times broader than long, as broad as the fifth pleaon segment anteriorly while it is broader and rounded posteriorly. The well developed uropods are shorter than the telson shield.

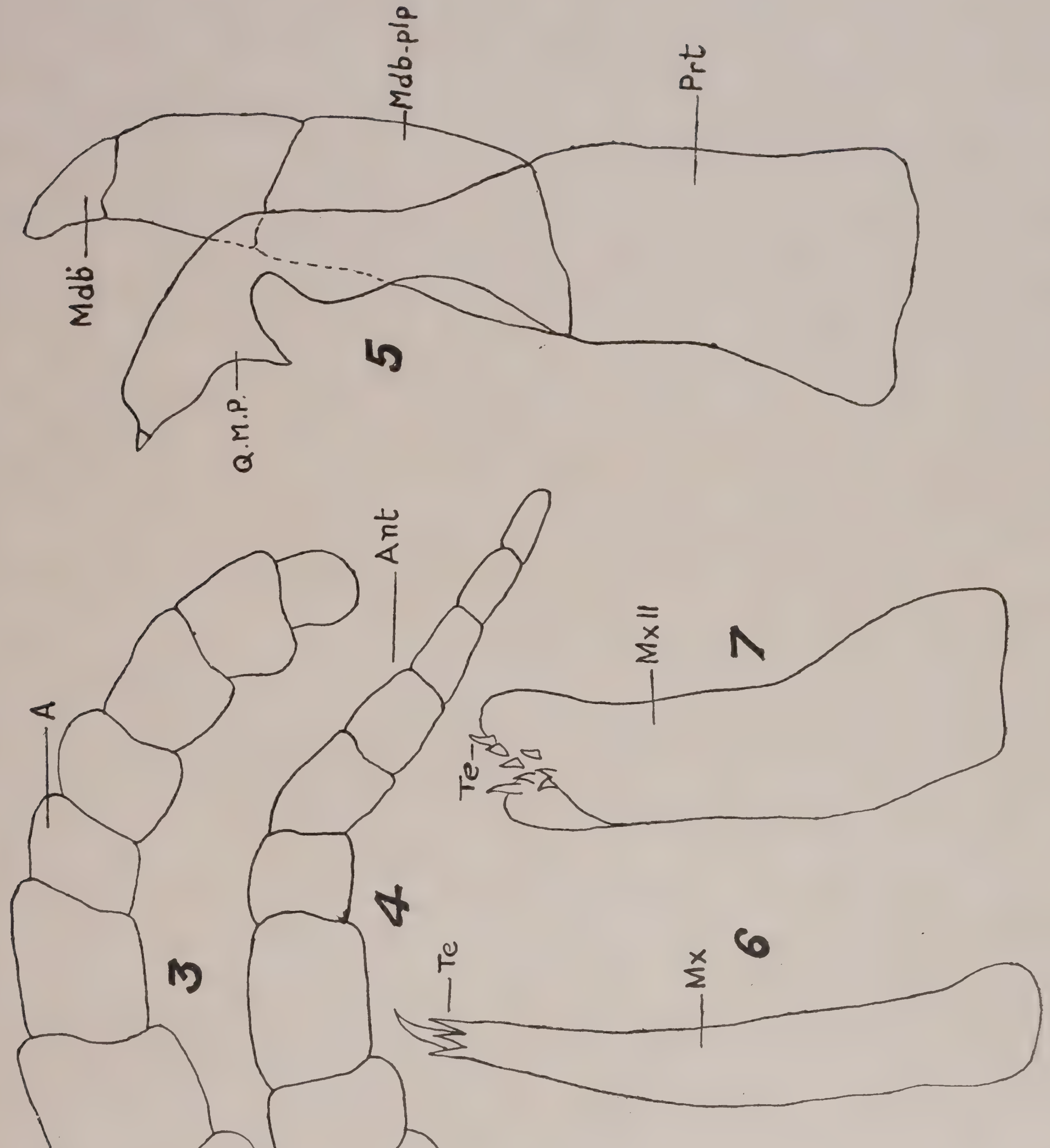
*Appendages.*—The *antennules* (Figure 3) are uniramous, more robust than the Antennae and widely separate at their bases. Each is eight-jointed of which the proximal three are very short while the distal five gradually taper towards the tip. The distal segment is blunt tipped.

The *antennae* (Figure 4) are very slender, filamentous, nine jointed and slightly shorter than the antennules though they look longer in situ. The proximal four segments are stouter than the distal 5 segments which are much more delicate and taper to a fine tip. The distal segment ends in a pointed tip. The distal segments of this appendage are very often found to lie curved over the cephalon dorsally.

The *labrum* is a thin white semi-lunar flap with a regular rounded posterior margin (not bilobed as in *I. nanoides*).

The *mandible* (Figure 5) consists of a well developed Protopodite and a three-jointed *mandibular* palp.

The stout base of protopodite narrows considerably, extends forwards and inwards and expands into a quasi-molar process as in I.nanoides which shows a concave bilobed



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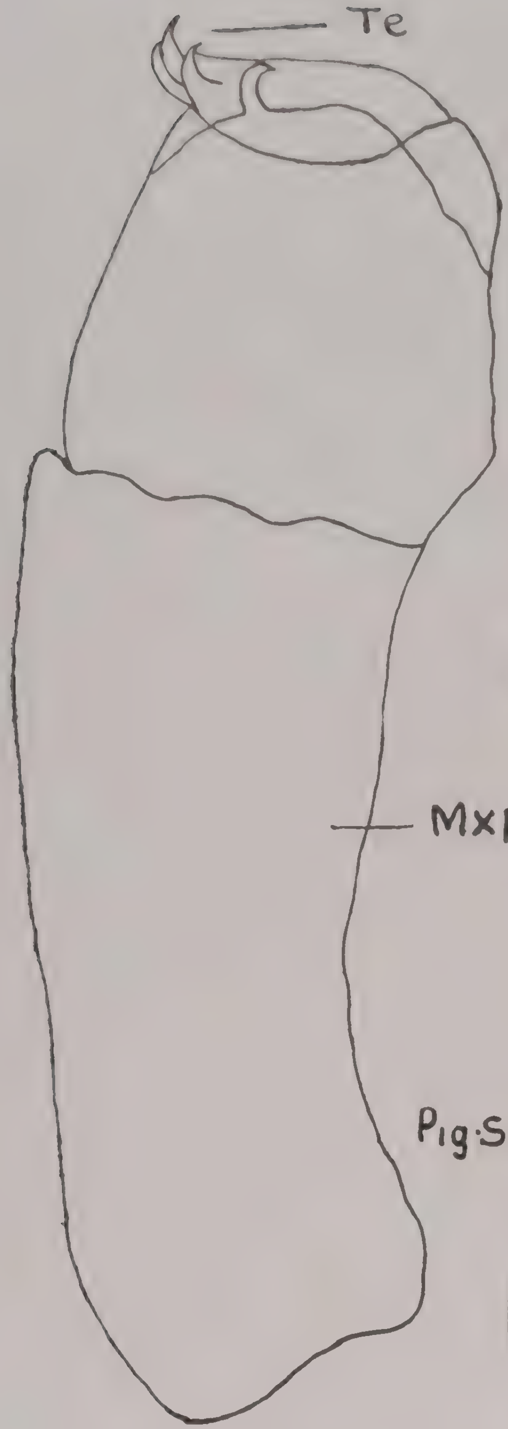

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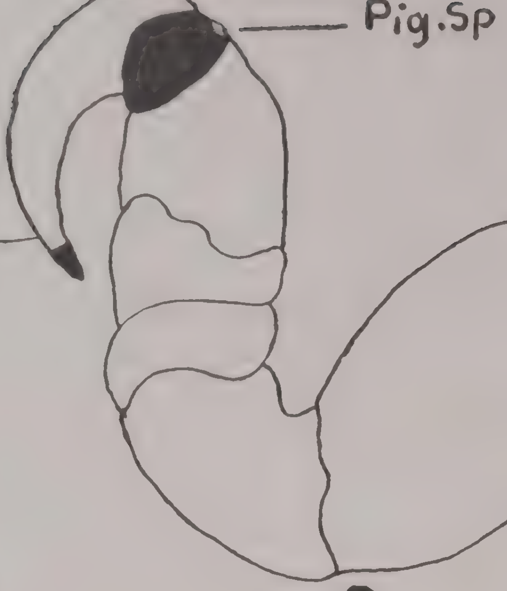

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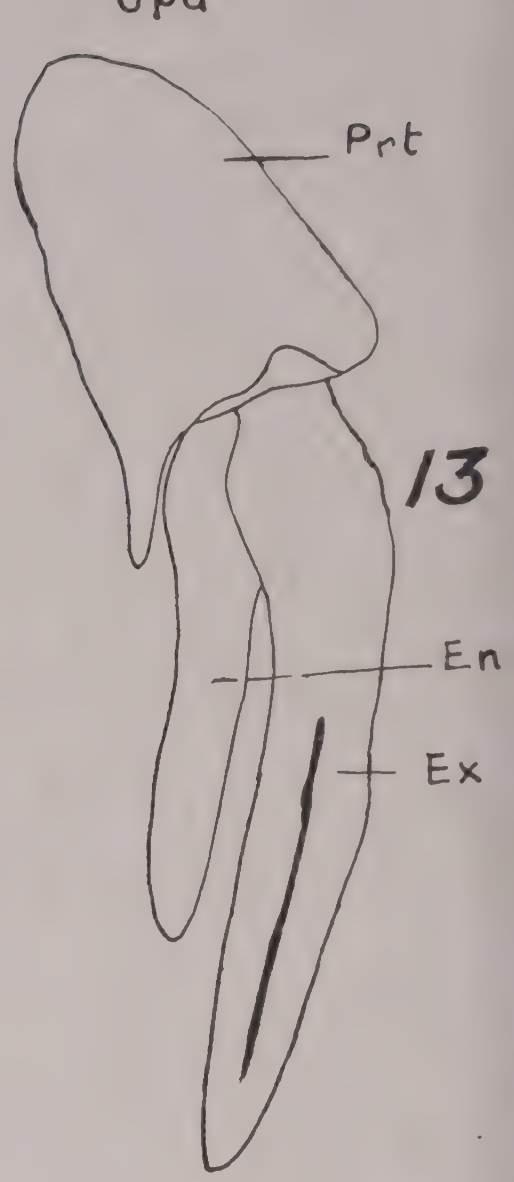

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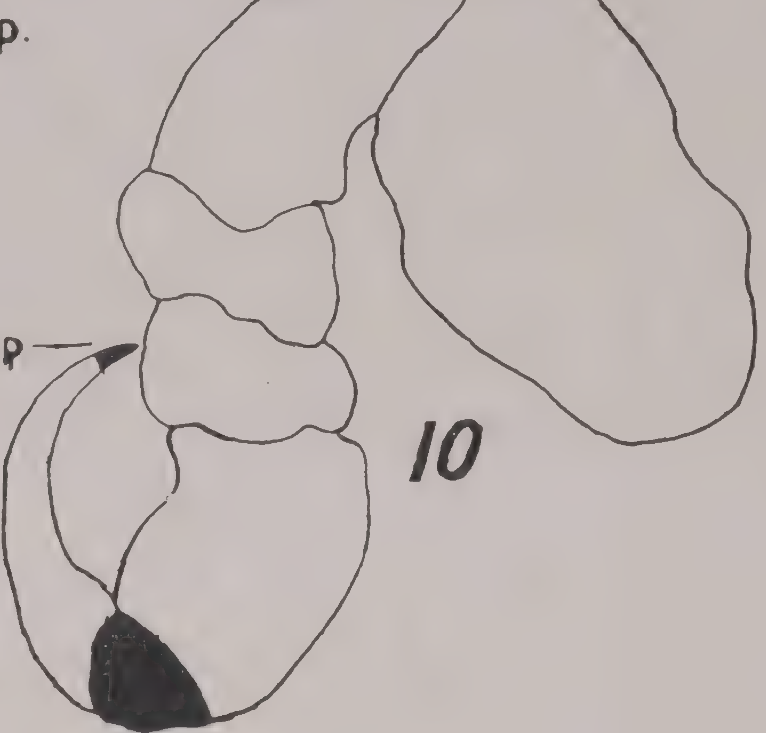

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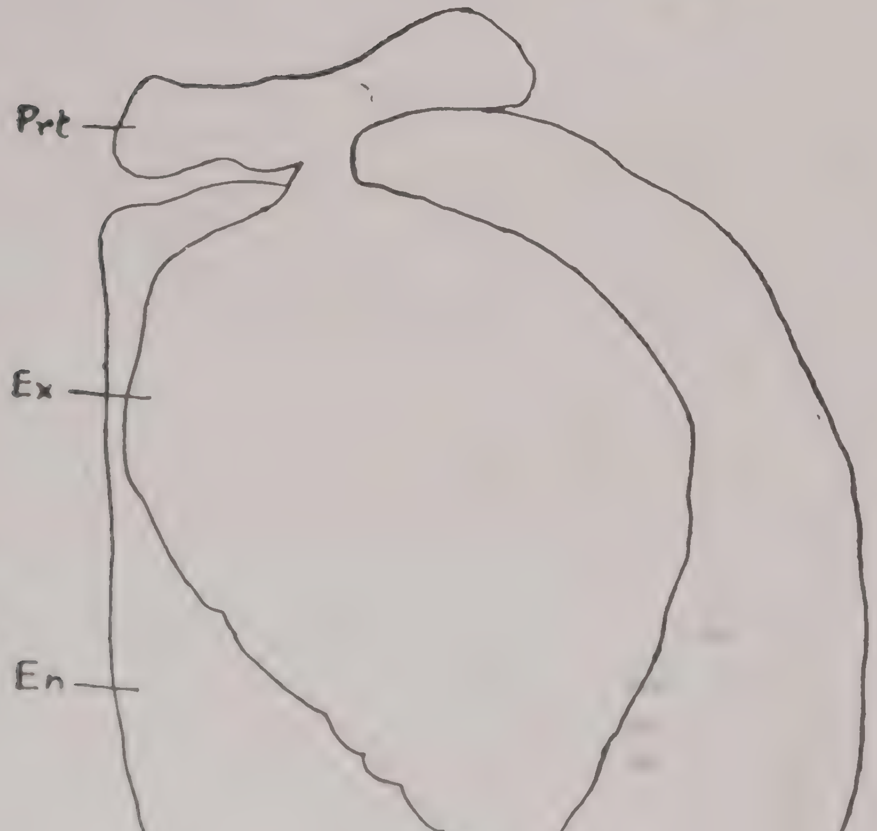

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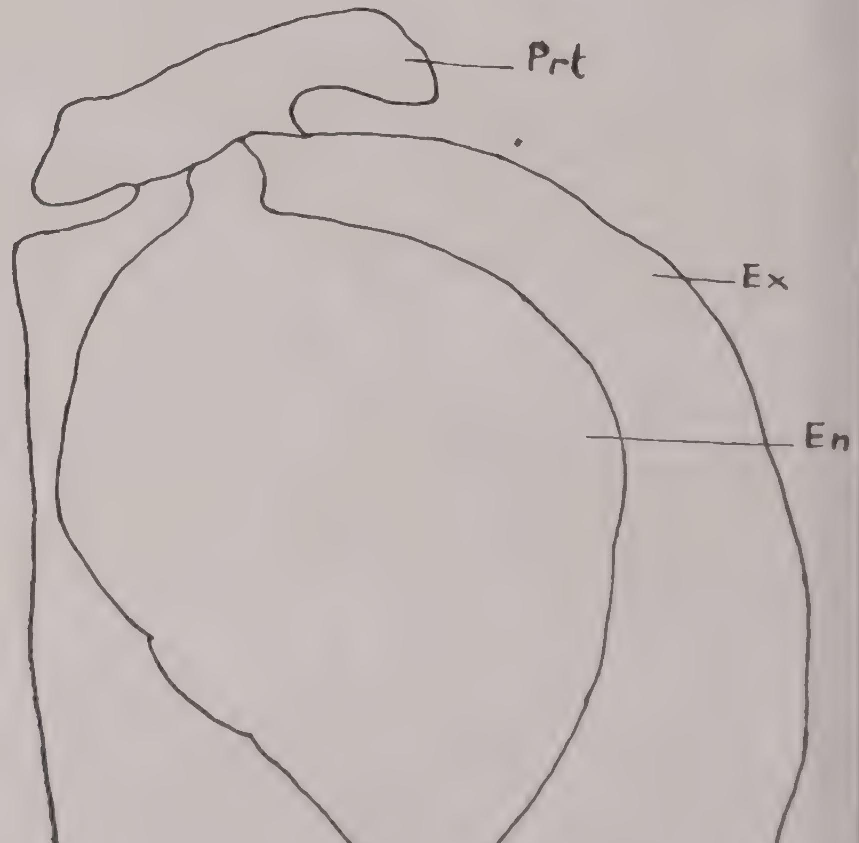

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toothed inner margin. Anteriorly it carries a brown tooth while there is a longer white tooth at its posterior end. In most cases, the narrow-base or neck of the quasi-molar process is almost entirely over-lapped by the palp. These processes lie just beneath the labrum. In *I.nanoides* the quasi-molar is much shorter than the palp. Hence it is very slightly shorter than the palp. The palp is about 0·95 mm. long and its segments taper gradually towards the tip. In *nanoides* the distal segments of the palp shows a curved spine and is setose. Here it is plain. The distal segment is short, roughly triangular and devoid of spines or setae. The palps curve round the edges of the cephalon in close contact with the eyes, their distal segments lying over the bases of the antennae.

The *I.maxilla* (Figure 6) is a simple more or less cylindrical appendage with a broad base and a narrow tip furnished with four sharp brown spines. It is about 1·2 mms. long and 0·25 mms. at its base. Of the four spines the outermost one is the longest and the other three are shorter and located at its base. These spines are very greatly curved at their tips.

The *II.maxilla* (Figure 7) are more prominent flat structures and cover the I. maxillae. Each is about 1 mm. long with a broader proximal end and a narrower distal one, which carries two unequal lobes of which the outer is about twice broader and slightly longer than the inner narrow shorter lobe. At the junction between the two lobes and at their free ends, there are about six to eight white transparent teeth. The number and size of teeth vary in this appendage. The teeth vary from 0·035 mm. to 0·05 mm. in length.

The *maxilliped* (Figure 8) as usual is three-jointed and measures about 2 mms. The basal joint is very long, broad and nearly twice the length of the second segment which is however as broad as the former and tapers towards the end to which is movably articulated the small short terminal joint which carries at its summit three outwardly and anteriorly directed white curved teeth. In a few forms an additional tooth is found at its base or junction with the second segment.

*I. Peraeopod* (Figure 9) is the shortest of all the seven pairs. The dactylus is directed towards the mouth and its pigmented tip reaches the base of the carpus. The basis is the stoutest of all the segments.

*VII. peraeopod* (Figure 10) is the longest of all the peraeopods. The basis is about 0·3 mm. thicker than that of the first pair. The claw is long and about 2 mms. in length and reaches the base of the carpus here also.

The pleopods are biramous foliacious structures capable of respiratory exchange. The protopodite is two jointed and very stout whereas the rami are very broad, oval, well developed and devoid of marginal fringe of setules. All are similar except in size.

*I. pleopods* (Figure 11) is the largest of all the five pairs. The exopodite is very broad, oval and arises from the outer region of the protopodite and covers the endopodite almost completely. Its free margin is more pointed than that of the endopodite. The latter arises from the inner half of the protopodite and is much smaller, and exposed only at its inner distal margins. The inner margin is more or less straight and the tip is blunt and rounded. No sexual characters persist in the *II pleopod* (Figure 12) as is met with in certain females of the group. There is no marginal setae. There are no coupling hooks in the margins of the protopodite.

The *uropods* (Figure 13) lie closely apposed to the sides of the well developed telson. Here unlike in males these are shorter than the telson well developed and about 5·1 mms. long. The protopodite is quite stumpy, longer than broad and carries a long pointed spinous process at its inner distal margin, internal to the point of origin of the endopodite. The exopodite is flat and flexuous elongated and narrow and about one and a half times longer than the endopodite. The latter is flat, shorter and narrower than the former but ends in a more or less sharp tip.

*The Male* (photos 2—4)—*Size and colour.*—The males vary in length from 13 to 18 mms. and are about half or two-thirds the size of females. A male 16 mms. long shows:—

| | L × B | |
|---|---|---|
| Head | 1·2 mms. | 2 mms. |
| Thorax | 9 mms. | 5 mms. |
| Abdomen | 6 mms. | 4·5 mms. |
| Telson with uropods | 5·2 mms. | wide. |

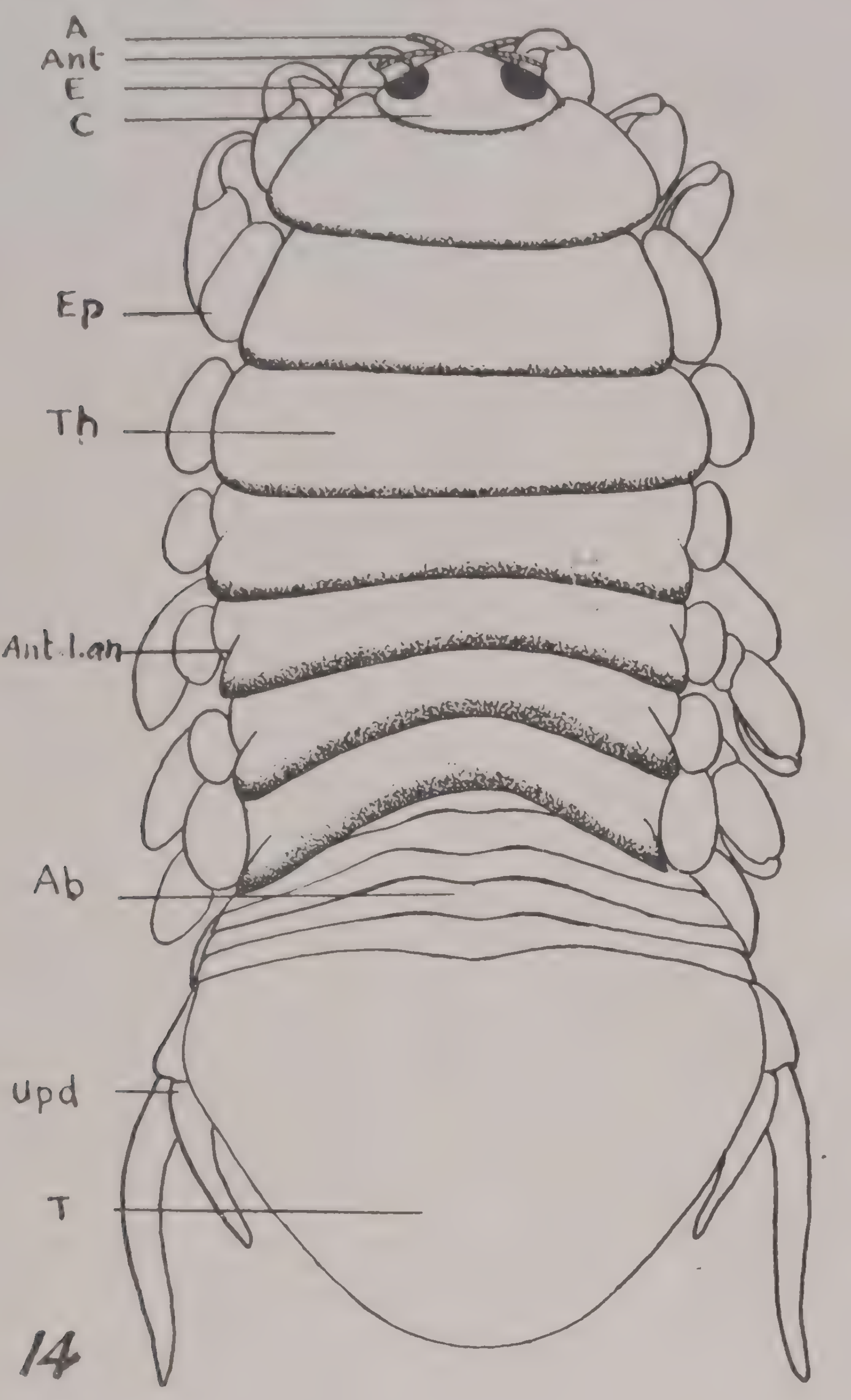
*Colour.*—Brown with all or few of the anterior or posterior segments showing pigmented striations (Photos 3 and 4).

The epimera telson and uropods are white in all males.

The claws show the pigmented tips and the pigmented areas in their bases (Figure 15) as in females. The pigment cells lie scattered in the cephalon and antennal pairs.

*General appearance.*—The body is more symmetrical than in females and is nearly thrice as long as broad. The broadest region of the body is at the third thoracic segment. The cephalon is small roughly triangular and its front edge is folded over the antennae. The eyes are more prominent than in female being about 0·5 mm. in diameter. The thorax forms the major length of the body, its first segment being broader than the cephalon and the anterolateral angles are short, blunt and extend up to the posterior margin of the eyes. It is slightly shorter than the succeeding two segments. The second is longer than the first but shorter and narrower than the third. The third is the broadest and longest of all the thoracic segments. The last four segments gradually decrease in size. The posterior margins of the fourth and fifth are slightly concave while that of the last segment is very concave into which the slightly broader abdominal segments are tucked in. Though the epimera of all the segments but the first are distinct as in female, here they differ to some extent. Those of the second and third segments are elongated and broader than those of the following four segments. Of the posterior four pairs, those of the last pair are broader and larger than the others. The posterior margin of the epimera of the sixth segment lies over the anterior margin of the following epimera. The anterior four pairs do not overlap each other in males. None of the epimera reach the posterior margins of the respective segments. Those of the sixth and seventh almost reach.

The antero-lateral angles of the last three segments are very clearly marked (Figure 14) while those of the fourth segment are slightly indicated. Those of second and third are not indicated at all. The peraeopods are onger in proportion to the size of the body than in females. The *abdomen* is slightly broader than the thorax and is very slightly immersed in the thorax. The first segment is almost hidden while the other four segments are distinct. Unlike in female the lateral regions of the second segment is not hidden. The segments very slightly increase in length in the fifth segment as is observed in the female. The telson is well developed, broad, white and membranous with its posterior margin gently rounded. Unlike in female, the uropods are longer than the telson.



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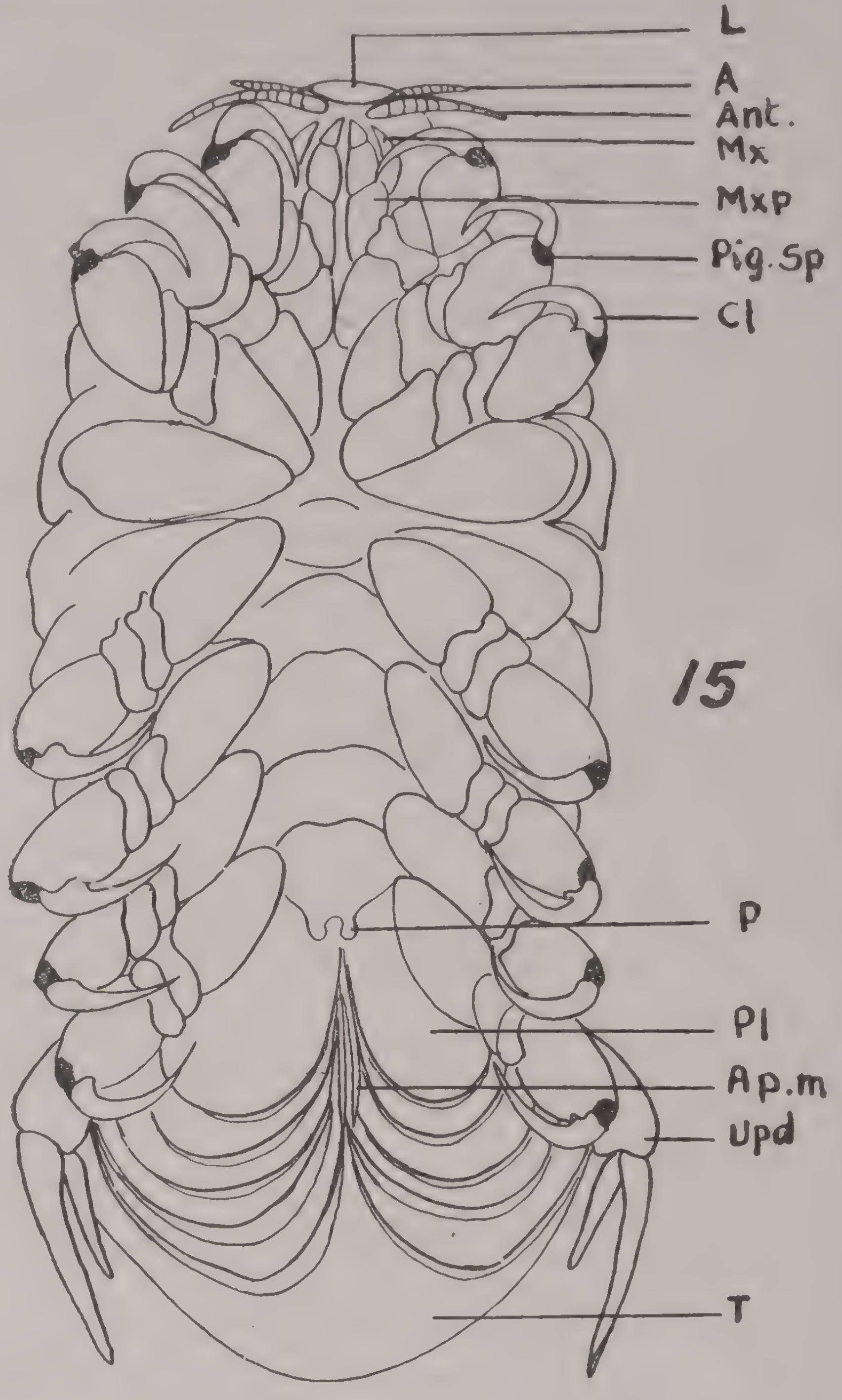
The ventral view of the male presents two important sexual features. The articular membrane existing between the last thoracic segment and the first abdominal shows in the mid-ventral line, two white club-shaped structures with rounded or slightly narrower tips. These are the penis (Figure 15). Each penis is about 0·4 mm. long 0·2 mm. broad at its point of origin from the body wall, and about 0·1 mm. at its tip. The endopodites of the second pair of pleopods carry at their bases slender elongated style like appendix masculina about 1·75 mms. long and 0·2 mm. thick at the base.

*Appendages.*—The antennules (Figure 16) are similar in structure to that of female. It is nearly the same length as in female and eight-jointed.

The *antennae* (Figure 17) are shorter and more slender than the antennules and are nine-jointed. The proximal three segments are massive, the fourth is longer than the former but thicker than the rest and the terminal five oints are slender and elongated.



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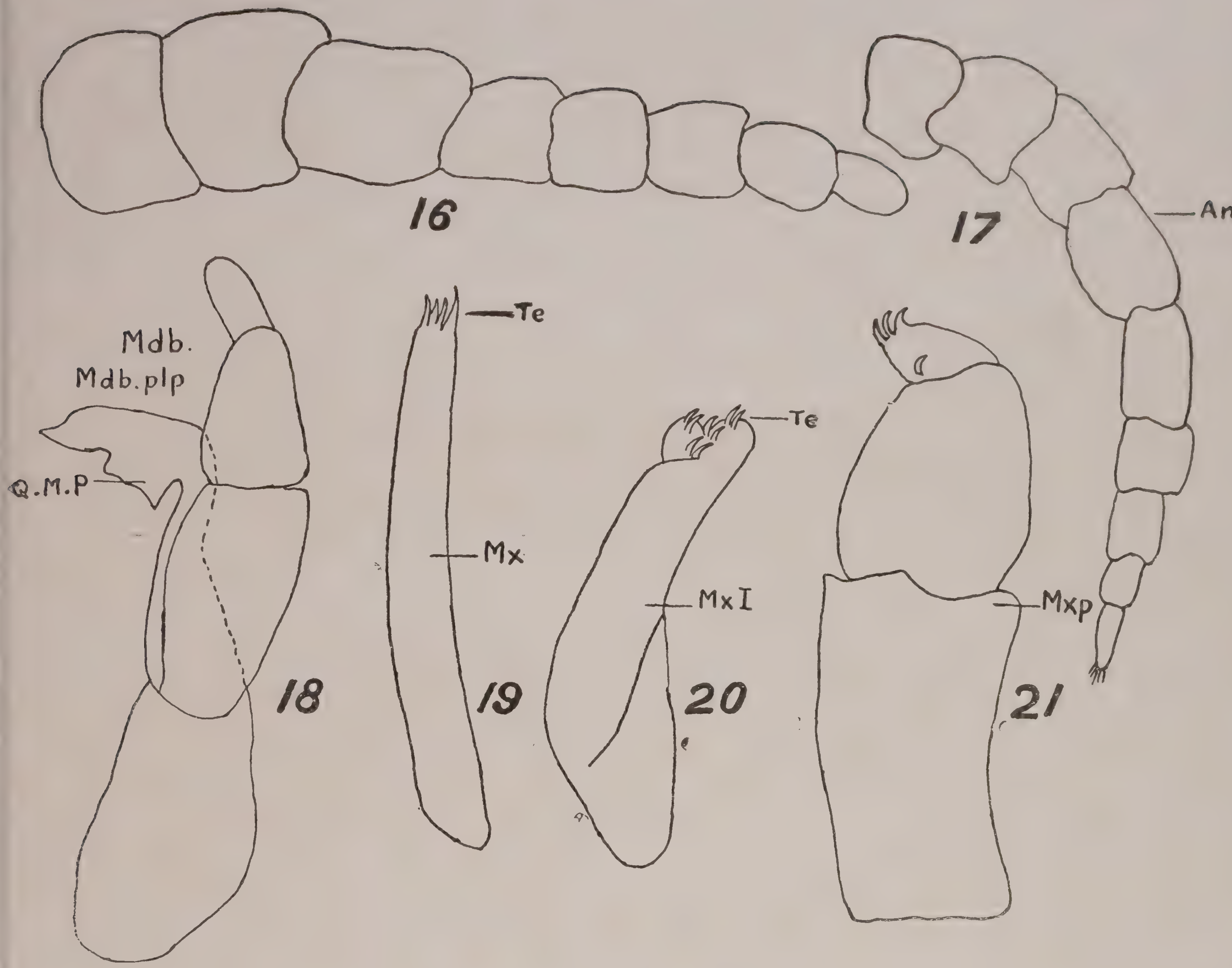
The terminal joint is pointed and setose, the setules varying from 0·04 mm. to 0·05 mm. in length.

The *mandible* (Figure 18) except in its smaller size agrees in general structure with that of female. The terminal segment of the palp is cylindrical with rounded tip and not triangular as in female. The anterior tooth of the quasi-molar process is not coloured here and the process has a narrow neck and broader base. The *I. maxilla* (Figure 19) is slightly shorter than that of the male but similar in structure. *II. maxilla* (Figure 20) very similar to that of the female. Here the number of teeth in the two lobes is constant. There are two sets of two teeth each in the outer lobe and two similar sets in the inner lobe. The *maxilliped* (Figure 21) is very similar to that in female, the relative length of the segments vary slightly. Here the basal joint is the longest and nearly one and a half times as long as the second. The distal segment is the shortest conical and carries three apical and one sub-apical outwardly directed curved teeth. In one out of the nearly ten



males studied, the distal segment showed about 9 teeth throughout its length. The teeth are about ·0·06 mm. long and longer than those of the *I. maxillae.*

The *I. peraeopod* (Figure 22) is the shortest of all with its basis being the stoutest and longest of all the joints. The Merus and carpus are the shortest. As in female the dactylus is curved and reaches up to the base of the carpus. The pigmented tip of the dactylus and pigmented area at the base, are present.

The 7*th peraeopod* (Figure 23) is the longest of all the thoracic appendages and no carina developed at the basis. The inner and outer margin of the distal end of the basis is produced into 2 short processes. This is not observed in the female. The dactylus and pigmented area are similar to those in female.

All the pleopods except the second pair are more or less similar in structure. A *typical pleopod* (Figure 24) consists of a short and broad protopodite. The exopodite is very large, springs from almost the whole breadth of the former, narrows gently posteriorly and covers the major part of the endopodite. The latter springs from the inner half of the protopodite, and is narrowed at its origin. Its inner margin is straight while its exposed free end is rounded unlike that of the exopodite. The exopodite and endopodite are nearly the same length. The *II. pleopod* (Figure 25). The short protopodite and exopodite are similar to those of other pairs. The endopodite is much smaller and shorter than the exopodite and almost completely hidden by it. Springing from the anterior inner margin of each of the endopodite is a styliform appendix masculina. This is about 1·75 mms. long, just reaches the posterior margin of the endopodite. It is nearly 0·2 mm. thick at its base and very much narrow at the tip. These are the appendix maculina and are supposed to aid in copulation. The *uropods* (Figure 26) are white in colour, well developed and longer than the telson in males. The stumpy protopodite shows two short processes on its inner and outer margins. That of the inner margin is very slightly longer than the outer.

My observations based on 102 specimens of *I. far* show the following differences :—

*Female*—1. *Colour.*—Live specimens show a yellow background with dark brown or black transverse striations. Epimera yellow or white telson uniformally white. Colour is not white with edges tinged yellow as described by Nair 1950).

2. *Coloured spots.*—Characteristic is the presence of dark brown or black triangular areas externally at the bases of the dactili at their junction with the propodi (Figure 2). The tips of dactili are dark brown. These have not been mentioned by Nair (1950).

3. *II. antenna.*—Nine-jointed and slightly shorter than the antennae and *not* eight jointed.*

4. *Mandibles.*—With three-jointed palp and a well developed protopodite which extends forwards and inwards and expands into a quasi-molar process as in *I. nanoides* which show a concave bilobed toothed inner margin. The spine at the anterior tip is coloured brown. The terminal joint of the palp is triangular and pointed at the tip.

The quasi-molar is not the distal segment of a two segmented ramus of the mandible as described by Nair (1950).

5. *II. maxilla* is unequally bilobed with 6-8 transparant spines usually eight spines in four sets of two each and not three and two in each lobe.

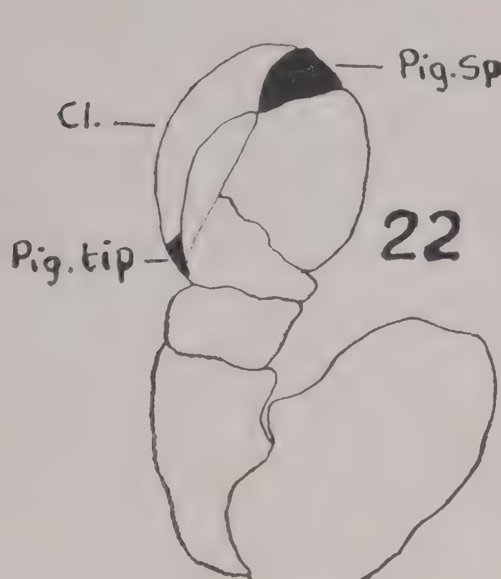
6. *Maxilliped* consists of three outwardly and anteriorly directed white curved spines. In a few forms there is an additional spine at the base at its junction with the second segment. This additional spine has not been described by Nair (1950).

7. *Anterolateral angles.*—Anterolateral angles of all the thoracic segments except first are marked by oblique grooves. No mention about anterolateral angles is made in Nair's description.

8. *Pleopods.*—Description of pleopods by Nair is meagre and incomplete.

9. *Telson* is well developed and broadly rounded and *not semi-circular* as described by Nair (1950).

1. *Male—Colour.*—Live male parasites show brown background with all, or few of the anterior or posterior segments showing the pigmented striations (the segments



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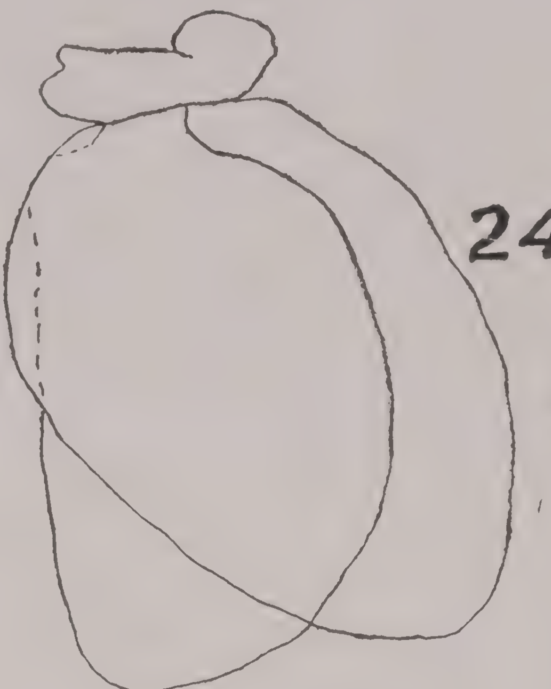

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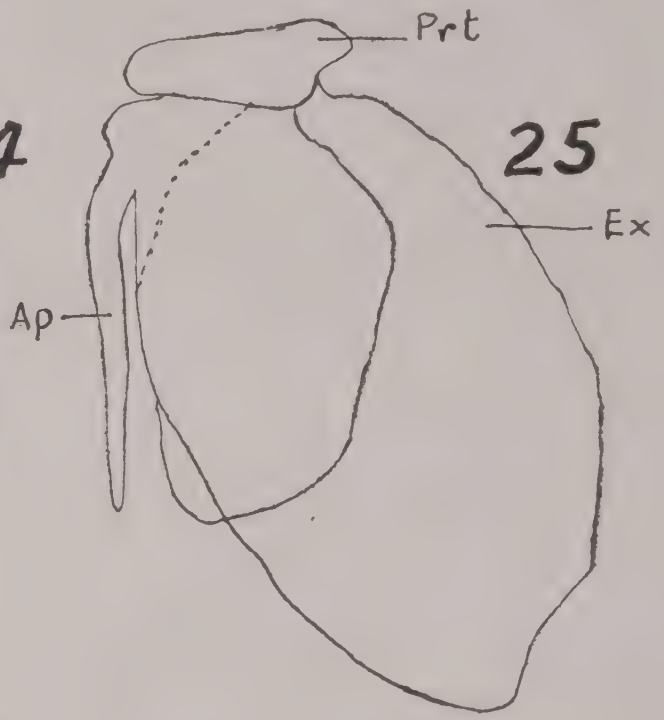

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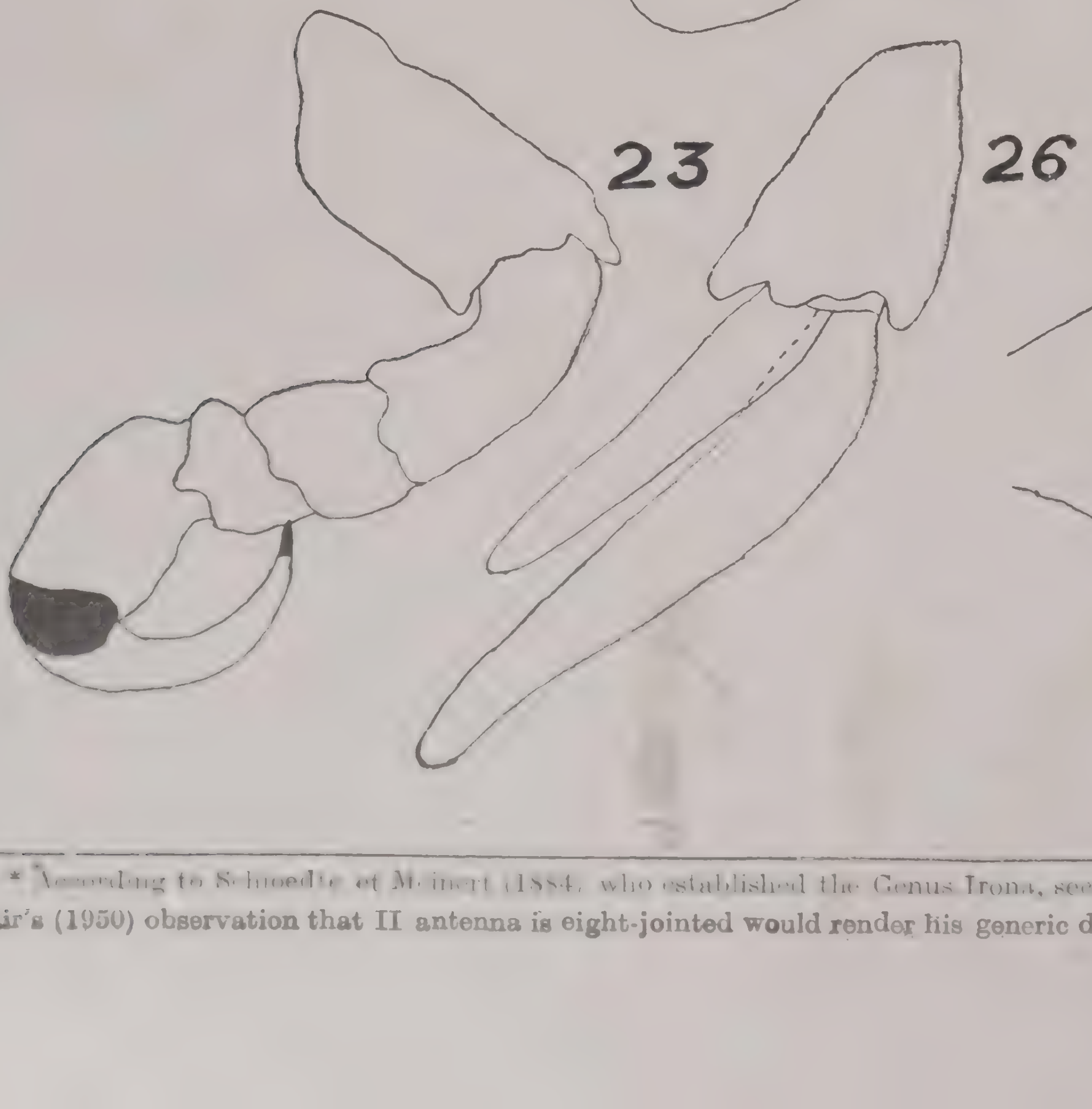

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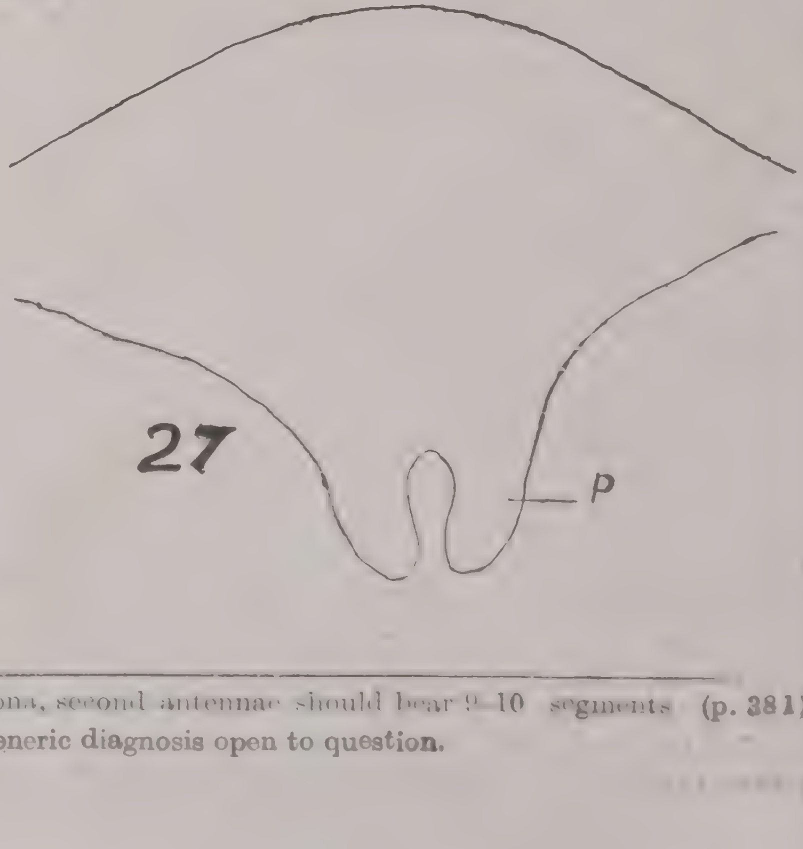

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* According to Schioedte et Meinert (1884, who established the Genus Irona, second antennae should bear 9–10 segments (p. 381) Nair's (1950) observation that II antenna is eight-jointed would render his generic diagnosis open to question.

not showing the striations being white in colour. This white colour is observed to be soon after moulting of that portion of thorax takes place).

The epimera, telson and uropods are white in all males. Colour is not same as that of female are much paler as described by Nair (1950).

2. *Pigmented areas.*—Claws of all the peræopods show dark brown tips and the pigmented areas at the bases of dactili as in females. This has not been mentioned by Nair.

3. *II antenna*—are shorter and more slender than *I*, antenna, nine jointed, the terminal joint being pointed and setose—not described beyond saying that appendage resemble those of females.

4. *Mandible* with a three jointed palp the terminal joint being cylindrical with a rounded tip and not triangular as in females. The anterior spine of the quasimolar is not coloured as in female. This is not described by Nair.

5. *I maxilla* as in female.

6. *II maxilla* the number of spines in the two lobes is constant being always eight. There are two sets of two each in each of the two rami of the II maxilla.

7. *Maxilliped*—Usually with four outwardly and forwardly curved spines at the distal segment. However, the number of spines may vary up to nine in some specimens.

The cephalic appendages of males have not been described.

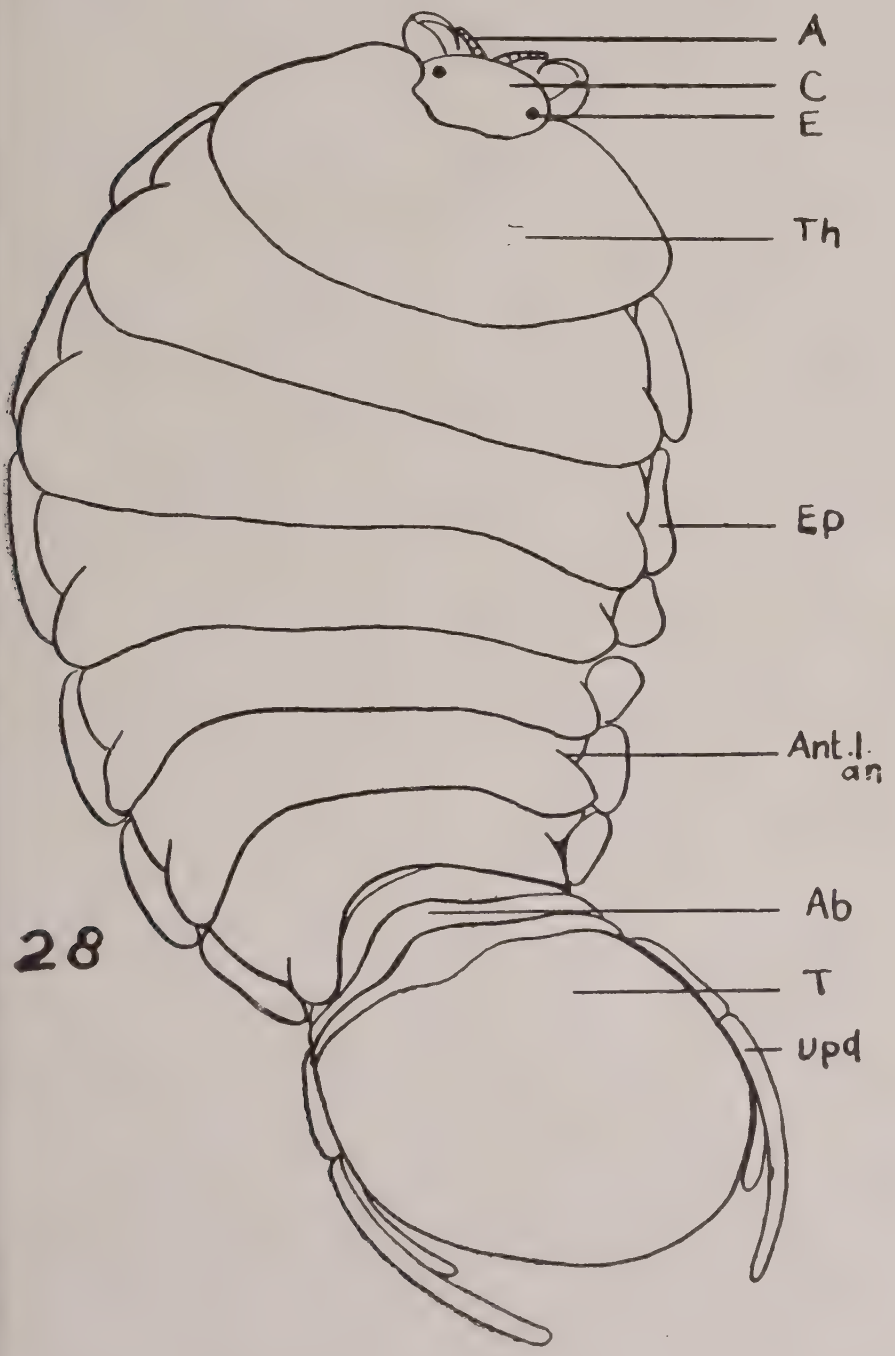
8. *Antero-lateral angles* are present from the fourth —7th segments and not marked in second and third thoracic segments as in the females. This has been omitted in Nair's account.

9. *Peraeopods.*—The inner and outer margins of the distal ends of the bases are produced into two short process in the seventh peraeopod of males. Peraeopods are not adequately described.

10. *Pleopods.*—In the mid ventral line two club-shaped penis (fig. 15) occur in the articular membranes existing between the last thoracic and first abdomenal segment. Similarly a pair of appendix masculina are also present in the endopodites of second pleopod.

11. *Uropods.*—Longer than telson.

Pleopods, uropods, and sex characters not described by Nair (1950).



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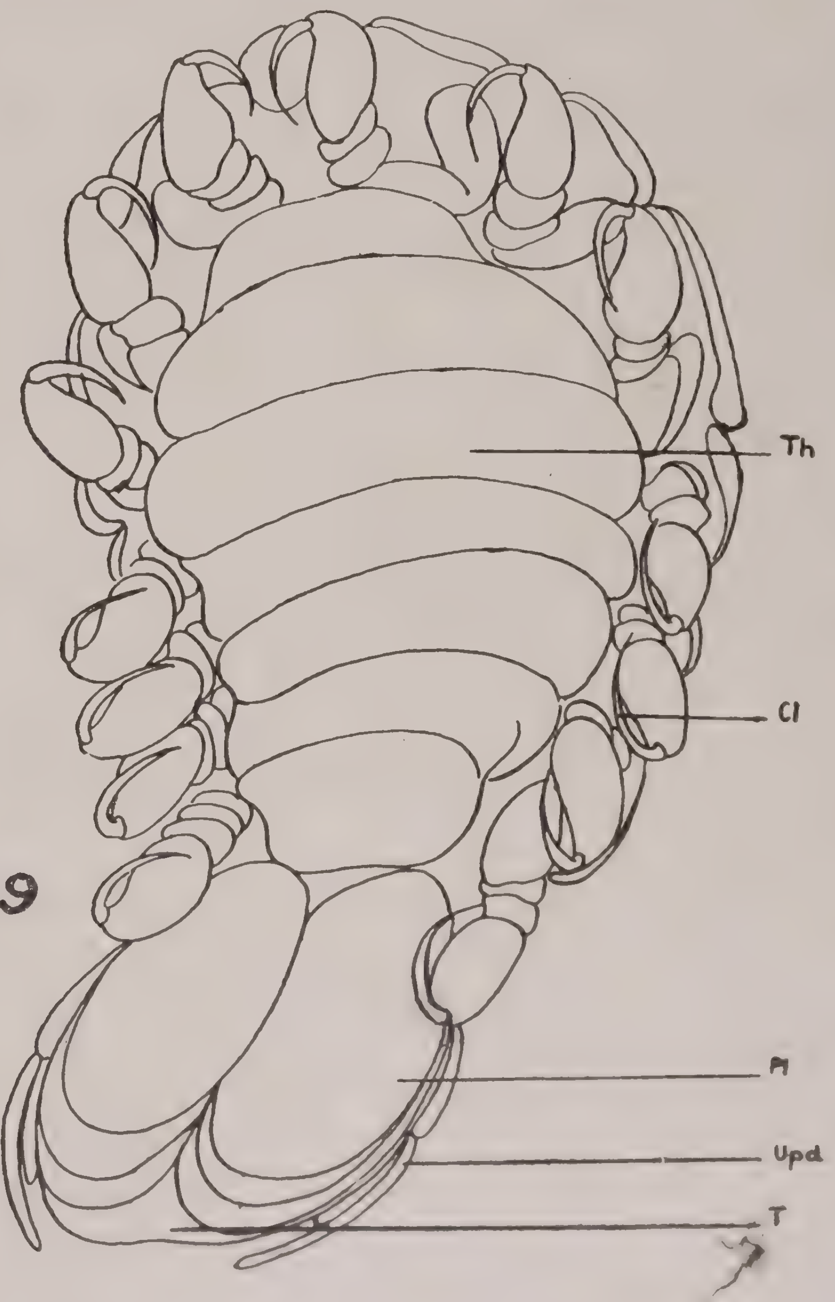

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A revised account of the specific characters of *Irona far* is given below :—

(1) Large sized female nearly 2½ times as long as broad whereas male is thrice as long as broad.

(2) Female with yellow ground colour and dark brown segmental striations. Male brown ground colour and brown bands. The tips of claws black.

(3) Mandible very much similar to that in nanoides with a quasi-molar (stebbing) shorter than the palp.

(4) I Maxilla with only four spines (unlike in nanoides and melanosticta where it is said to be five).

(5) II maxilla unequally bilobed with four pairs of teeth.

(6) Conspicuously large membranous telson more than 1½ times broader than long with a rounded posterior margin sometimes even wider than the widest region of the body.

(7) Uropods shorter than telson in female but longer in males.

(8) Epimera of second and third thoracic segments narrower and smaller than those of last four pairs which are broad and flat. In male the anterior two pairs of epimera are larger than the posterior four pairs.

(9) Antero lateral angles of all the thoracic segments excepting the first, marked by oblique grooves in females. In males those of second and third segments not marked off as in female, the last four segments only showing the antero lateral angles.

(10) Dark brown triangular areas at the bases of the dactyli in both sexes is very characteristic of the species.

2. *Irona robusta.*—Between July to October 1948 while collecting cymothoan parasites 90 specimens of this parasite were collected from the gills of *Tylosurus Lieurus* (Photos 5 and 6) of which 25 were males.

*External features—Female* (Photos 5 and 6).—The largest female measured 31 mm. in length (Figures 28 and 29)

Length—31 mm.

Breath—14 mm.

Telson—8×7.

*Locality.*—Madras.

*Host.*—Parasitic on gills of Tylosurus lieurus.

*Body.*—Asymmetrical, twisted to right or left so that one side is longer than the other.

*Cephalon.*—Small, squarish with two dark circular eyes located in the mid lateral margin, rather deeply sunk in the concavity of the anterior margin of the first thoracic segment.

*Thorax.*—The first segment is distinctly much longer than the remaining thoracic segment. The second and the third are nearly half the length of the first and the remaining four slightly shorter. The segments are longer at the sides than at the mid dorsal line and much longer on one side. Body is broadest at the third thoracic segment from where it gradually narrows up to the seventh segment, which unlike the rest is very concave posteriorly and lodges the abdominal segment. The epimera as usual are not distinct in the first segment. Those of the second and the third are narrow and do not reach the posterior margin of the segments. Those of the remaining four are much longer and larger on the longer side, the last two reaching the whole length of the respective segments. On the shorter side the last four are not longer than the preceding two but are short and slightly broader. Those of the fourth and fifth only nearly reach or do not reach the posterior margin of the segment. Those of the sixth and seventh reach the posterior margin of the segment.

The antero lateral angles are very distinctly marked on the last four segments faintly indicated on the second and the third while they are absent with first segment.

*Abdomen* is slightly broader than the seventh thoracic segment. The first abdominal segment is completely hidden and the second almost completely hidden by the seventh thoracic segment. The third is only partially covered laterally and the last two are fully exposed. Thus the last three segments are distinct and the second is faintly visible in the middle. The fifth segment is markedly longer than the proceeding ones.

Telson is broader than long, rounded nearly as broad as the last abdominal segment. The uropods (Figure 40) are much longer and reach beyond the posterior margin of the telson both the rami ending in rounded tips. The endopodite is much narrower and shorter than the exopodite.

Ventrally on the shorter side the four posterior pairs of legs (Figures 36 and 37) are seen closely set and smaller in size than those on the longer side. All the seven pairs of legs end in curved claws with sharp tips.

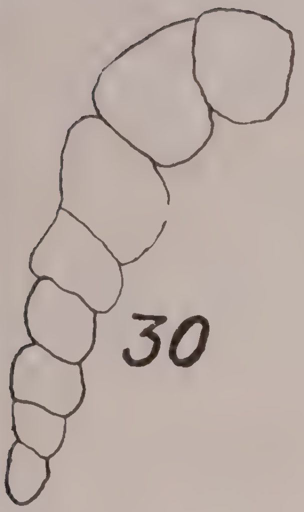
*Colour.*—White, with telson light grey in few.

*I. Antenna* (Figure 30).—Eight jointed, the joints gradually tapering. The terminal joint is rounded.

*II. Antenna* (Figure 31).—Nine jointed more delicate and longer than the first.

*Mandible* (Figure 32).—With a quasi-molar as in *nanoides* and *I. far* but extending anteriorly beyond the palp. It has a convex inner margin which carries a spine anteriorly and posteriorly. The palp is three-jointed and curved inwards. The distal joints being narrow and pointed. The protopodite is quite stout and longer than the palp but shorter than the quasi-molar.

*I maxilla* (Figure 33).—With four teeth one of which is conspicuous. *II. maxilla* (Figure 34) bilobed distally and broad basally. The outer lobe carries three curved spines directed outwards while the inner carries one spine only.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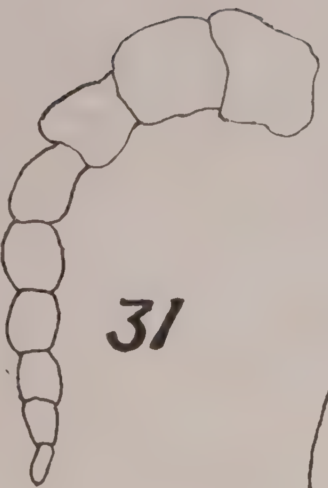
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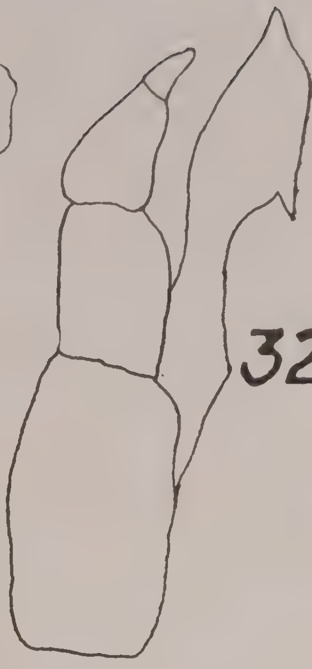
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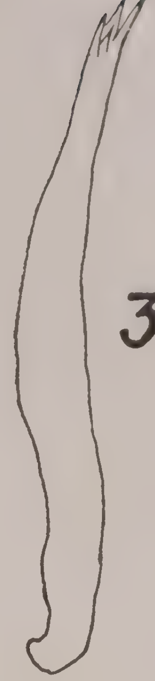
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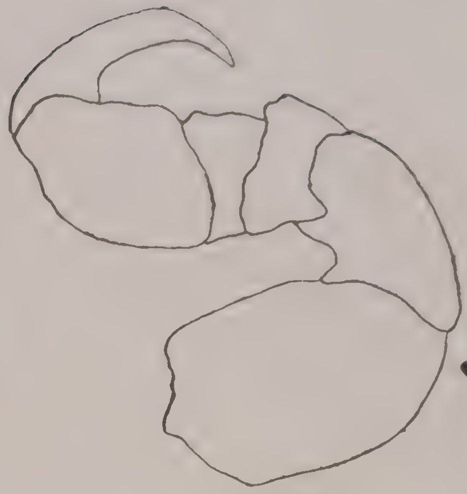
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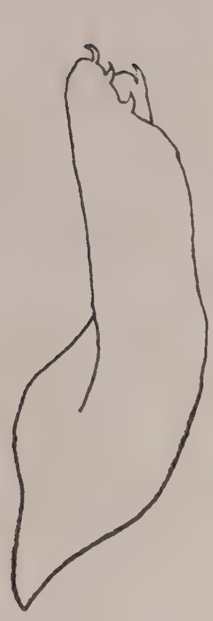
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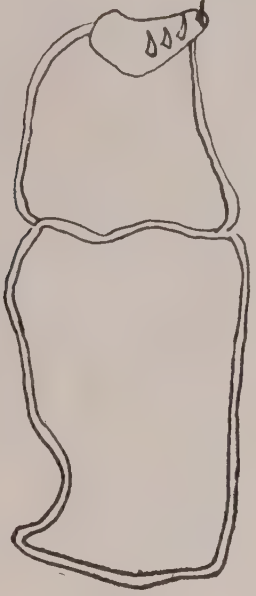
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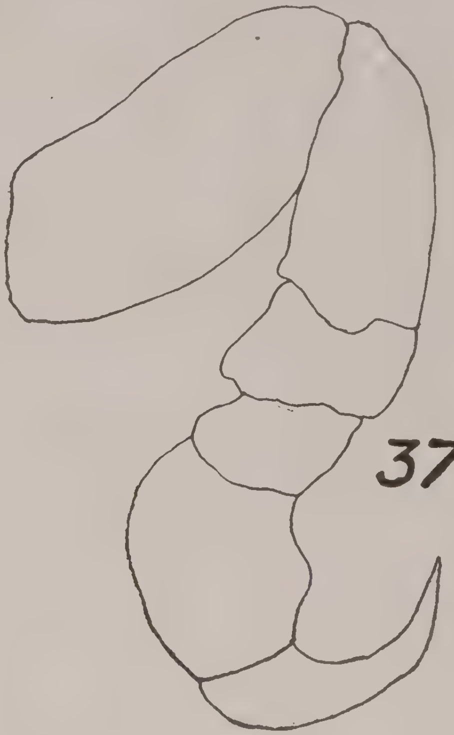
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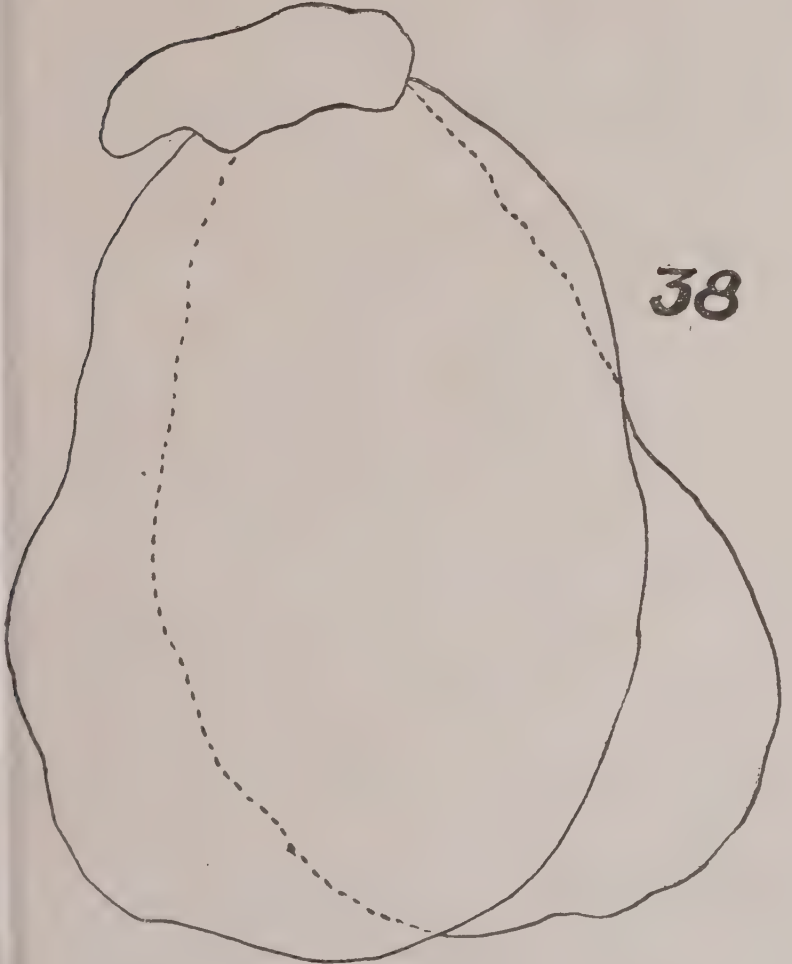
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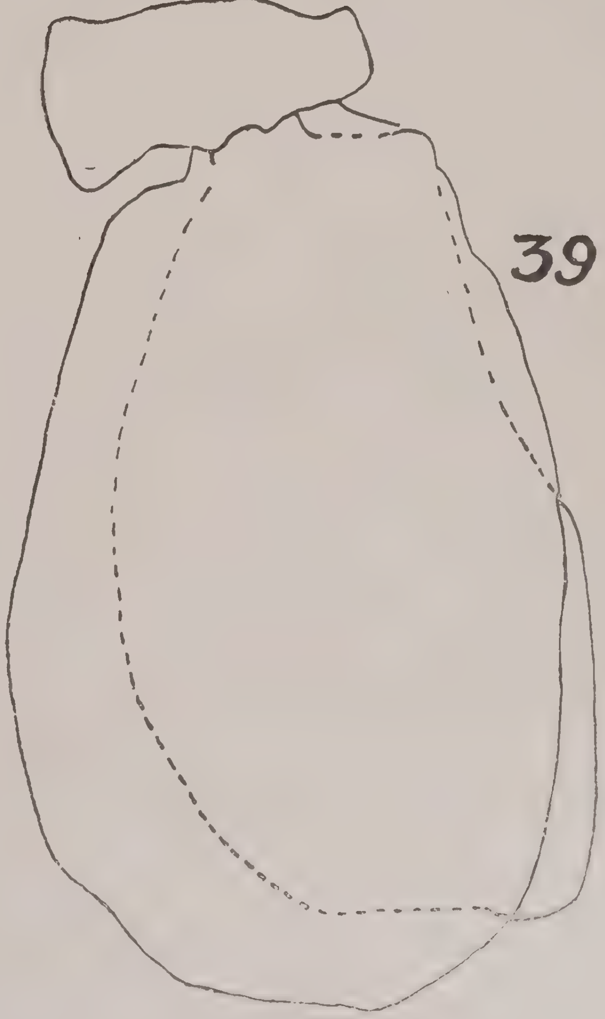
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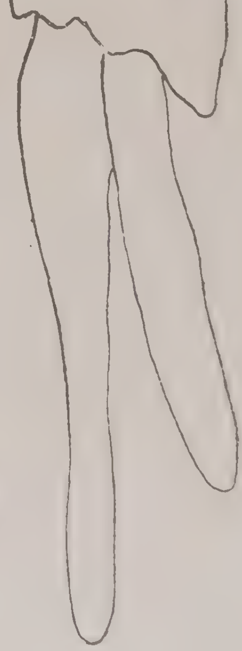
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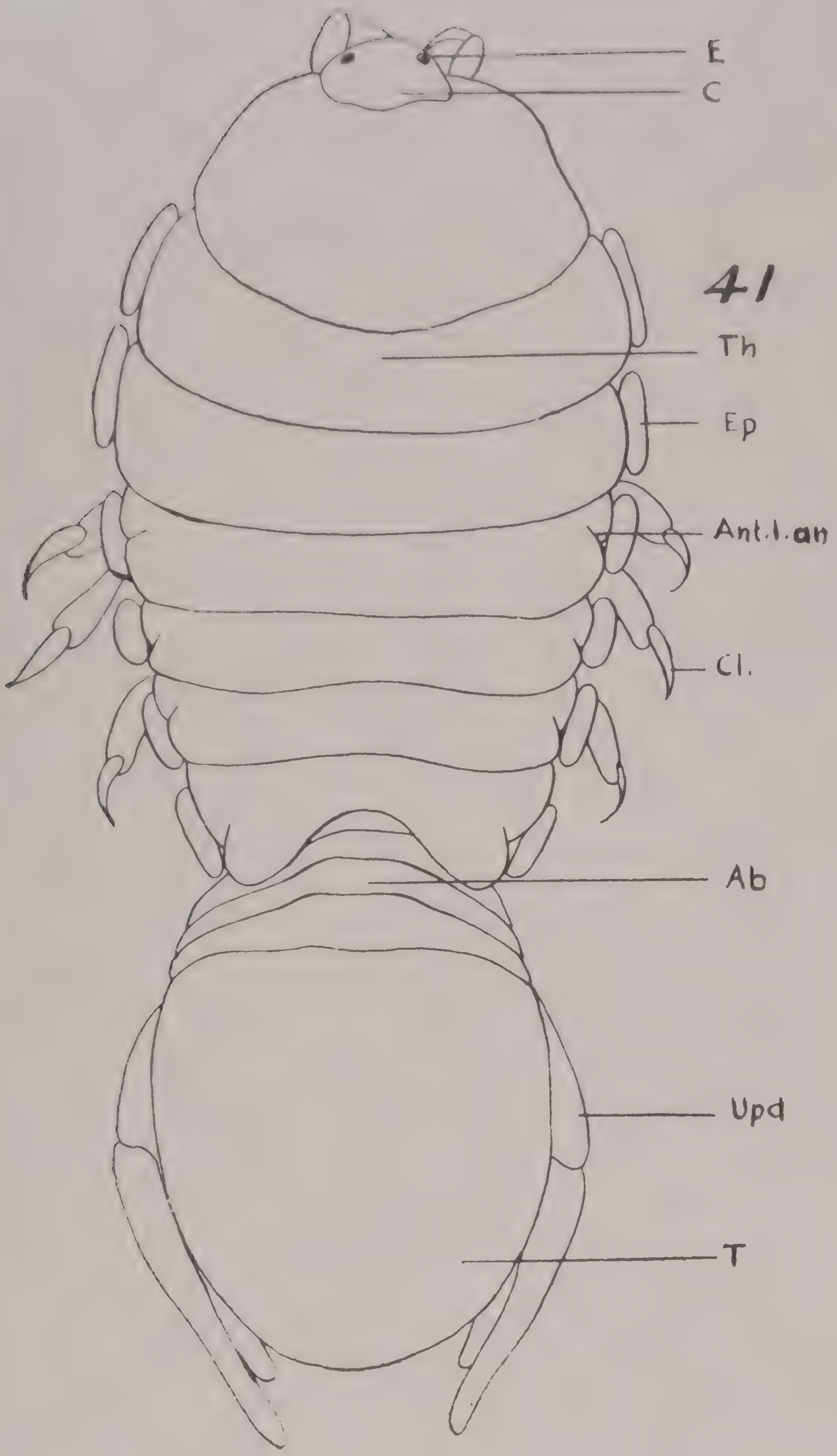
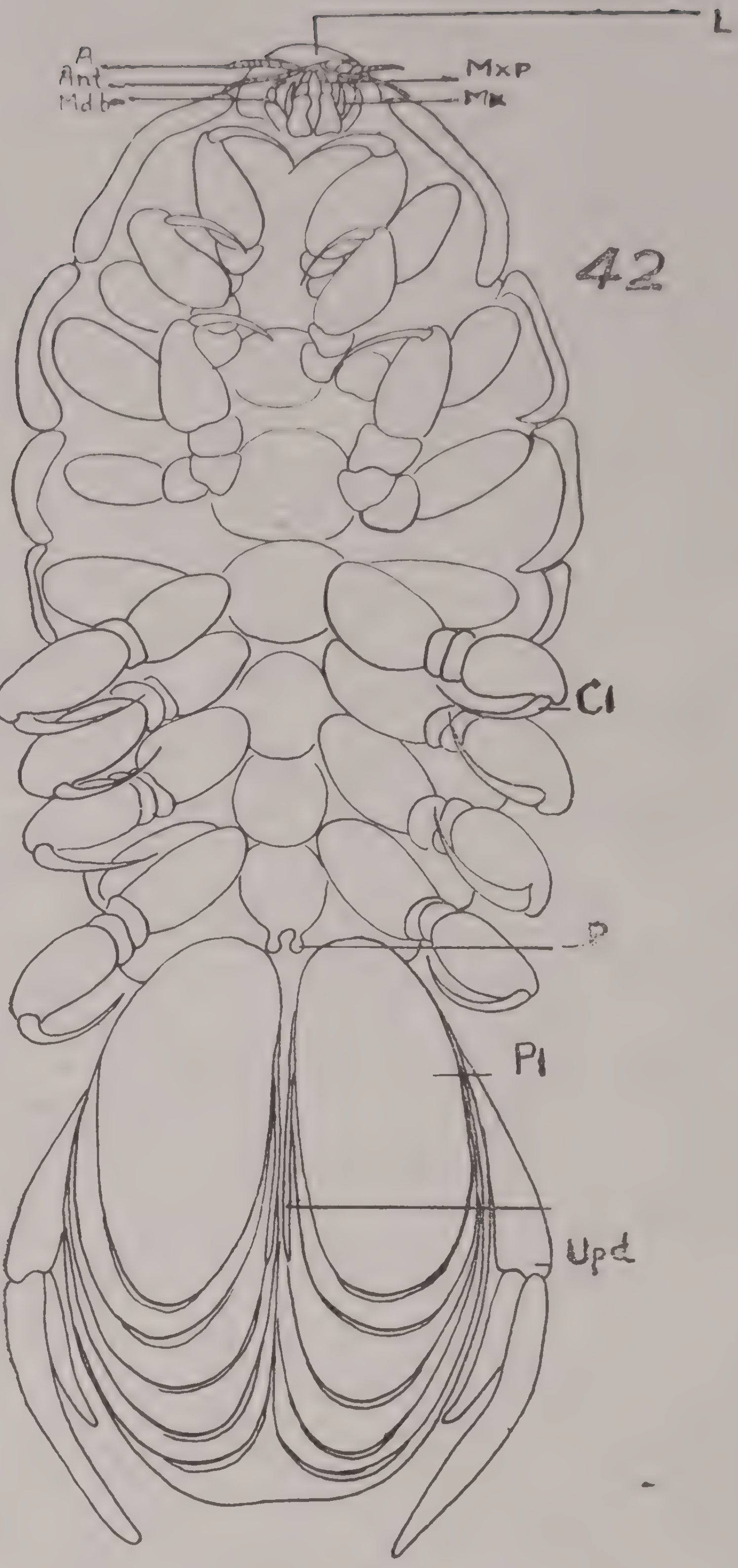




*The maxilliped* (Figure 35) is three-jointed, the basal being the largest. The terminal joint is conical and carries four curved sharp spines directed outwards.

*Male.*—Length—20·5 mm.

Breadth—8 mm.

Telson—4·5 mm × 4 mm.

*Colour.*—Light purple or light brown in live specimens.

The largest male (Figures 41 and 42) so far collected is 20·5 mm. long and 8 mm. broad.

*Body.*—Symmetrical, pear-shaped broader at the anterior end and gradually narrows posteriorly.

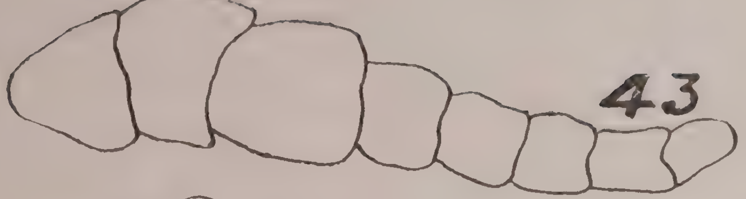
*Head.*—Dark, brown in colour, semi-circular rather immersed in the thorax.

*Eyes.*—Very dark and seem to function.

*Thorax.*—The first segment is markedly longer than the succeeding ones as in the female. The second and the third are nearly equal in length, the forth is slightly shorter in length and the rest gradually decrease in length. The thorax is widest at the second and the third segment from where it gradually narrows. The last thoracic segment is concave posteriorly and completely covers the first and part of the second abdominal segment. The remaining three segments are distinct, their length gradually increases posteriorly.—The second segment is more exposed than in the female.

*Abdomen* is almost as broad (Figure 54) as the telson which is slightly longer than broad. Uropods are longer than the telson.

*The epimera* of the second and third segment are the largest and only almost reach the posterior margin of the segment. Those of the last four pairs are nearly half the size of the preceding two and are placed slightly dorsally, i.e., above the level of the second and third epimera. Those of the fourth and fifth do not reach the posterior margin of the segment while those of the sixth



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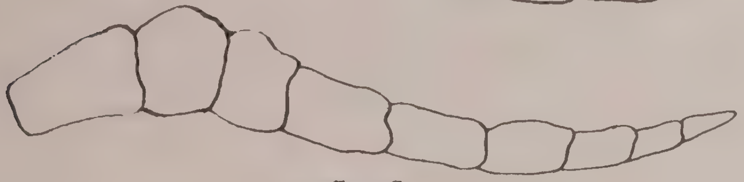

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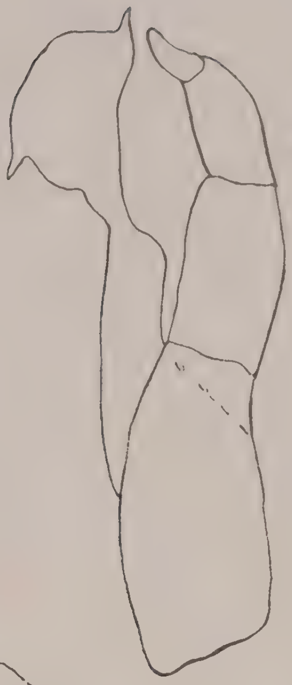

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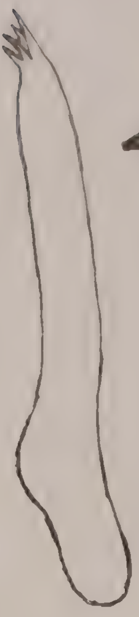

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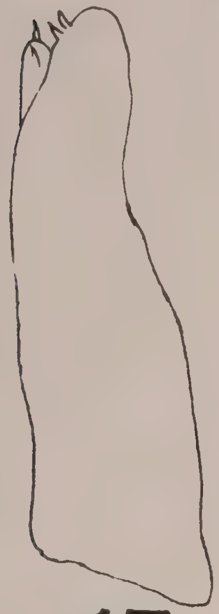

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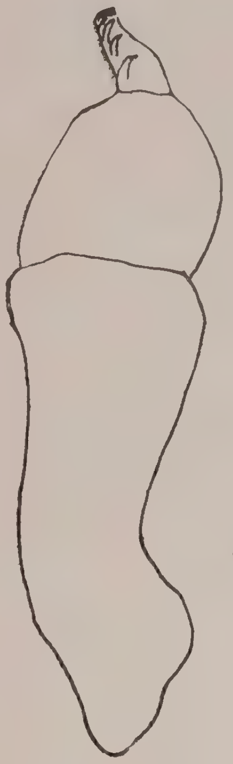

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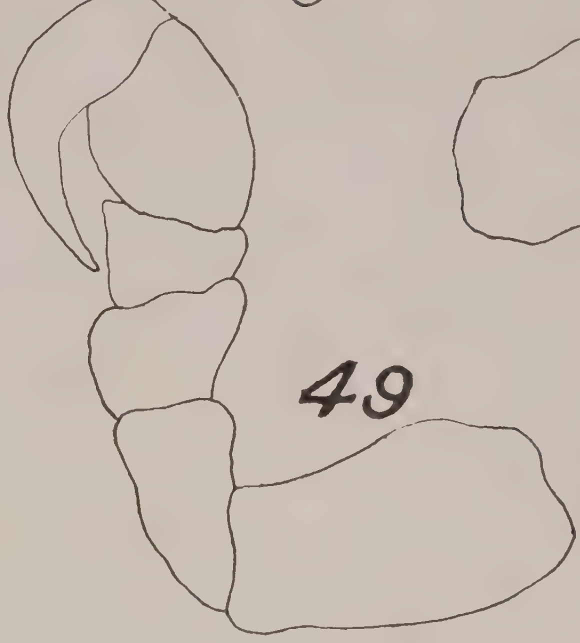

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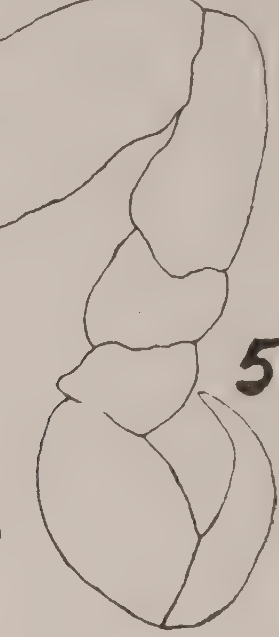

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and seventh reach. The smallness of the last four pairs of epimera and the slightly dorsal position are interesting. The antero lateral angles of the last four pairs are only marked distinctly. Those of the second and third are not marked as in the female. (This has been observed by Barnard in the Male of *I. malanosticta* also).

*The legs* (Figures 49 and 50) are more slender than those in the female. The first three pairs are folded forwards and inwards towards the mouth, while the last four are kept folded backwards and outwards. The claws are sharp and curved and reach the base of the fourth segment.

*Ventrally* on the posterior margin of the seventh thoracic segment is present a pair of very short penis with rounded tips (Figure 51) . A pair of appendix masculina are also present in the endopodites of the second pair of pleopods (Figure 53).

*The antennal* pairs are smaller than the female but similar in structure (Figures 43 and 44).

*Mandible* (Figure 45)—The quasi-molor is shorter than in female and has a constricted neck region.

*The I and II maxillae* (Figures 46 and 47) similar to that of the female.

*The maxilliped* (Figure 48)—The appendage is more elongate. The basal segment is more than twice longer than the second one. The distant segment is veryshort conical and carries four outwardly directed curved teeth.

My observations based on 90 specimens of *Irona robusta* differs from the description of Nair in the following :—

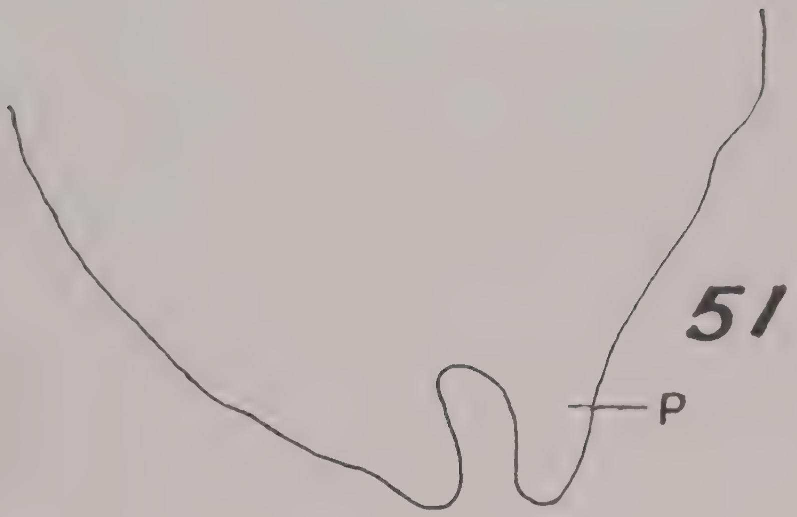
1. *Female—Colour*—White with telson always light gray in live specimens colour of telson not mentioned.

2. *Size* parasites ranged from 20—31 mms: Nair has recorded a size range of 24—28 mms. only.

3. Description of abdomen, pleopods, etc., meagre and incorrect.

4. *Antero lateral angles* absent in first thoracic segment, faintly indicated in second and third and distinctly marked in the last four thoracic segments.

5. *Epimera*—Not distinct in first. Those of second and third are narrow and do not reach the post-margins of the segments. Those of fourth seventh are much larger and longer on the longer side, the last two reaching the whole length of the respective segments. On the shorter side those of fourth to seventh are much shorter than those of the second and third segments and are broader. Those of the fourth and fifth almost or nearly reach the posterior margin of the respective segments where as those of the sixth and seventh just reach the posterior margin of the respective segments. Description given by Nair is very incorrect.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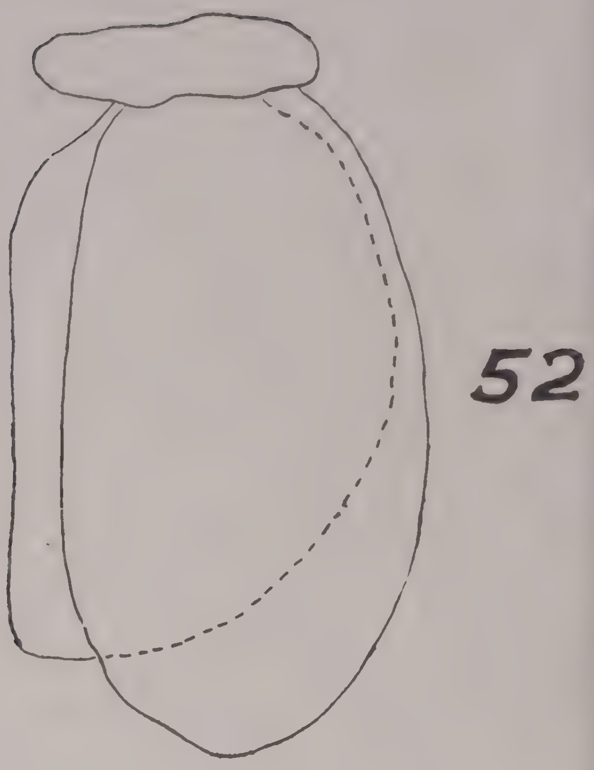
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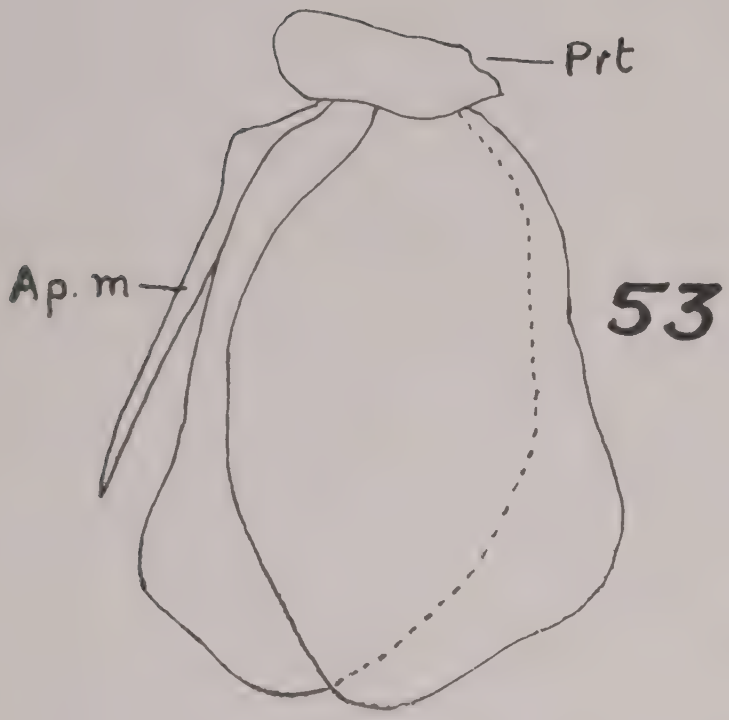
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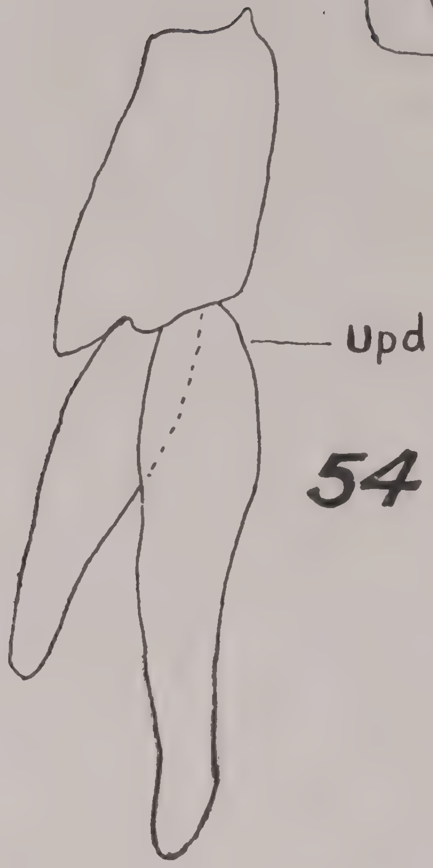
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6. *I. antennu.*—The terminal joint of the eight-jointed antenna is always rounded. This is not mentioned by Nair.

7. *II. antenna* always nine-jointed and *not eight jointed* as described by Nair.

8. *Mandible.*—(Figure 32) with quasi molar as in *I. nanoides* and *I. striata* but extending beyond the three-jointed palp. The palp is not two-jointed as described by Nair.

9. *II maxilla* (Figure 35) is distinctly bilobed with the outer lobe carrying three outwardly directed spines and inner lobe with one spine —not three on the inner and two on the outer.

10. *Maxilliped* (Figure 36) the number of spines in the distal segment of the appendage is uniformly four and not five as described.

11. *Pleopods* (Figures 38 and 39)—The exopodite of the pleopods are always broader than the endopodite and almost cover the latter. The exopodites are not narrower than the endopodites as described by Nair.

1. *Male—Colour.*—Light purple or light brown in live specimens. Males are more symmetrical than females. The colour is not mentioned by Nair.

The general description of males is meagre.

2. *I. antenna.*—Eight jointed with terminal segment rounded and blunt not more acute as described.

3. *II. antenna*—Nine-jointed. Details of joints not given.

4. *Mandible I and II maxilla* are not described.

5. *Antero lateral angles and epimera* not described.

6. The II abdominal segment is less covered in male than in females.

7. A pair of penis and a pair of appendix masculina are present in males which are not described by Nair.

# A DETAILED KEY TO THE KNOWN SPECIES OF IRONA.

| Species | *I. melanosticta.* | *I. foveolata.* | *I. nanoides.* | *I. nana.* |
|---|---|---|---|---|
| Locality | S. Australia, Africa, Japan Sandwich Island. | S. Africa | Ceylon | America |
| Host | *Hyporhamphus intermedius Belona* sp. *Tylosurus chorum.* | .... | .... | *Hemiramphus* sp. |
| *Other Characters :* | | | | |
| 1 Size | ♂ 15 × 6 mm. ♀ 22 × 13 mm. | ♀ 20·5 × 10·5 mm., 14·5 × 8·2 mm. | ♀ 10 × 5·5 mm. | ♀ 8—18 mm. |
| 2 Colour | Yellowish white with faint bluish tinge. Telson except posterior margin bluish black. | Yellowish with dark dots. Telson, grayish, Epimera white. Lat. Angles of 5 ab. segments white. Almost whole telson is grayish. | Yellow, epimera whitish | Yellow with large or small dark branching spots arranged in transverse rows scattered over the middle of the body. |
| 3 Head | ♂ Proportionately longer in males. | .... | .... | Small, sub-triangular or sub-conical, ⅓rd or ¼ th as wide as the 4th segment of the thorax. Much wider than long, deeply immersed. |
| 4 Relative length to breadth. | ♂ 2½ times as long as broad. ♀ 1¾ times longer than broad | Nearly twice as long as broad. | Nearly twice as long as broad. | Body subovate or ovately produced, 1½ or 2 times as long as broad. (5 : 3 or 2 : 1). |
| 5 Upperlip (Labrum). | Faintly emarginate | Not four lobed as in *I. nanoides.* | .... | .... |
| 6 I. Antenna | Peduncleand flagellum not distinct eight jointed. | Not described | Eight jointed | Rather compressed eight jointed and widely separated. |
| 7 II Antenna | Ten jointed | Do. | Ten jointed | Nine jointed subfiliform |
| 8 Mandible | Palp stout without setae. | No vomerine teeth in the quasimolar process, four spines in terminal joint. Stout first joint for the palp. Protopodite with a quasimolar process. | Not described | Not described |
| 9 Maxilliped | Apex with three hooked spines. | Not described | Two apical hooks plus one Subapical hook. | Do. |
| 10 I. Maxilla | Apex with three spines the other two appear to be broken off. | Do. | Tipped with five spinules | Do. |

## the known species of Irona

| *I. far.* | | *I. renardi.* | *I. robusta.* | |
|---|---|---|---|---|
| Madras | | S. **Australia** | **Madras.** | |
| *Hemiramphus far* .. .. .. .. . | | *Tylosurus ferox T. macleayana*, and other T. species. | *Tylosurus* ***Lieurus.*** | |
| ♂<br>12—18 mm.<br>16×5·5 mm. | ♀<br>22×9 mm.<br>18—26 mm. | 20 mm. long | ♂<br>20·5 × 8 mm. | ♀<br>31×14 mm. |
| Brown ground colour with dark brown striations. Sometimes few of the anterior or posterior thoracic segments without striations. Epimera and telson white. | Yellow with dark brown or black transverse segmental striations. Epimera yellow or white. Telson white. | .... | Light purple or light brown. Head dark brown in colour. | White with telson always light grey. |
| Dactyli with brown tips: Brownish circular areas at the junction of the dactyli with propodi in all the peraeopods of both sexes is characteristic. | | | | |
| Small roughly triangular. | Very small and nearly one fourteenth of the total length and is deeply set in the thoracic segment. | .... | Semi-circular; rather immersed in the thorax. | Small squarish and deeply sunk in the first thoracic segment. |
| Nearly thrice as long as broad. | Nearly 2½ times as long as broad. | .... | Nearly 2½ times as long as broad. | More than twice (nearly 2¼ times) as long as broad. |
| Simple .. .. .. | .... | .... | .... | .... |
| Eight jointed .. | .... | Eight jointed .. .. .. | Eight jointed .. | Eight jointed. |
| Nine jointed .. | .... | Nine jointed .. .. .. | Nine jointed .. .. | Nine jointed. |
| Palp not setose in females. Similar to that of nanoides, the quasi-molar process with anterior brown spine and posterior white sharp tooth. | | Not described .. .. .. | The quasi-molar is shorter than the palp with a constricted neck region. | With a quasi-molar extending anteriorly beyond the palp. The palp is three jointed. |
| Varying from 4 to 8; usually 4—3 apical and 1 sub-apical spine. | | .... | The basal segment is more than twice longer than the second. The distal very short and carries four outwardly directed curved spines. | .. |
| Four spines one of which is largest .. .. | | ... | Same as in females .. | With four teeth one of which is conspicuous. |

## A Detailed Key to

| *Species.* | *I. melanosticta.* | | *I. foveolata.* | *I. nanoides.* | *I. nana.* |
|---|---|---|---|---|---|
| 11 II. Maxilla | Two lobes each bearing three hooked spines. | | Not described .. .. | A membraneous apical margin plus a process carrying small hooked spines. | Not described. |
| 12 Nature of abdomen. | .... | | Lateral edges of first pleon alone overlapped. The five segments are very distinct. | First two pleon are overlapped, third and fourth and fifth distinct, short but wider than telson. | .... |
| 13 Pleopod | First and second exopodites broader but shorter than Endopodites. Male stylet shorter than endopodite extending two-thirds of it. Peduncle with prominent epipod. | | .... | .. . | .... |
| 14 Telson | ♂<br>Almost long as broad, apex broadly rounded. | ♀<br>As long as broad. | Pockmarked, very thin, large membraneous sometimes with distinct, very faint median keel on the dorsal surface. | Almost semi-circular and narrower than the last three pleon segments. | Narrowly sub-triangular, little narrower than 5th abdominal segment. Almost $1\frac{1}{2}$ times broader than long, $1\frac{1}{5}$ times longer than other abdominal segments. |
| 15 Uropods | Much longer than telson. Inner ramus one-third as long as telson, outer $1\frac{3}{4}$ times as long as telson. | | Shorter than telson, outer ramus shorter than the inner and with large and sub-acute end. | Shorter than telson, subequal oval branches little longer than peduncles. | Longer than telson, outer longer acute, sickle-shaped and flexuous. Inner shorter. |
| 16 Epimera | ♂<br>Pendulous Second and third deepest, posterior margin truncate, fourth small, fifth to seventh sub-equal and posterior margin rounded. | ♀<br>Second and third narrowest, fourth much the largest, sixth and seventh intermediate in size. | Second, third and fourth very narrow fifth broader and posteriorly more produced. Epimera of sixth and seventh much broader and more produced rising above the dorsal surface of the thorax and turned outwards and upwards. | Sixth and seventh are much broader and produced posteriorly than others. On each side they rise considerably above the lateral part of the dorsal surface so that these are turned outwards and upwards. | Epimera usually unequally produced. First three epimera narrow long and posteriorly rounded. The other three pairs rounded short wide, gradually increasing in width and truncately rounded. Anterior three do not reach the posterior margin of the segments but the three posterior epimera almost reach the posterior margin of the segments. |
| 17 Antero-lateral angles. | Second and third segments not marked off by oblique grooves in males as in females. Females sp. curved to the left. | | Not described .. .. | Figure shows in only fourth fifth, sixth and seventh segments in females. | Not described. |

the known species of Irona—*cont.*

| *I. far.* | | *I. ronardi.* | *I. robusta.* | |
|---|---|---|---|---|
| Bilobed with four sets of two spines each. Thus total of 8 spines. | | • | Same as in females .. | Bilobed outer lobe carrying three spines and inner carrying one spine. |
| ♂<br>Only first segment is hidden. The remaining four are very distinct. | ♀<br>First pleon completely hidden. Second overlapped partially, laterally the last three very distinct and second quite distinct. | Not described .. .. | ♂<br>Second Abdominal segment is less curved than in females. | ♀<br>Broader than seventh thoracic segment. First segment completely and second almost completely and third partially hidden by last thoracic segment. The last two are fully exposed. Fifth segment markedly longer than the preceding four. |
| In the one pleopod, exopodites and endopodite equal in length. Exopodite of eleven longer and the stylet as long as the short endopodite, No epipod in the peduncle. | | Eleven pair of pleopods with a pair of appendix masculina in the endopodites. | Second pair of pleopod with a pair of appendix masculina in the endopodites. | ♀ |
| Nearly 3½ times as long as the other pleon segments together. Large and white membraneous. More than 1½ times broader than long. | | Not described .. | Slightly longer than broad. | Broader than long. |
| ♂<br>Longer than telson. Exopodite longer than endopodite. | ♀<br>Shorter than telson, protopodite of females with a internal distal spine. | .... | ♂<br>Longer than telson .. | ♀<br>Much loner than telson |
| ♂<br>Those of second and third are larger than those of the following pairs. The posterior four pairs are smaller of which the last is the largest. All are narrow and elongate. Not oval or flattened as in females. | ♀<br>Those of second and third segment narrower and elongate those of the last four segments broad, oval and flattened. | .... | ♂<br>Epimera of second and third segment are the largest and almost reach the posterior margin of the segments. Those of the last four pairs are nearly half the size of the preceding two and placed slightly dorsally above the level of the second and third epimera. Those of fourth and fifth do not reach the posterior margin of the segments. Those of sixth and seventh reach. | ♀<br>Second and third are narrow and do not reach the posterior margin of segments. Fourth to seventh are much longer and larger on the longer side the last two reaching the whole length of the segments. On the shorter side, the last four pairs of epimera are not longer than the preceding two, but are short and slightly broader. |
| ♂<br>The last three only are clearly marked, that of fourth faintly indicated. Absent in the first three segments. | ♀<br>Antero-lateral angles of all thoracic segments but first are clearly marked off. | .... | ♂<br>Absent in the first segment marked only in the last four pairs of thoracic segments | ♀<br>Absent in first segment, faintly indicated in second and third segments and distinctly marked in the last four thoracic segments. |

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## KEY TO LETTERING.

1. A.—Antennule.
2. Ab.—Abdomen.
3. Ant.—Antenna.
4. Ap.m— Appendix masculina.
5. Ant. I. an.—Antero-lateral angle.
6. B.—Basis.
7. C.—Cephalon.
8. Cl.—Claw.
9. Ca.—Carpus.
10. D.—Dactylus.
11. E.—Eye.
12. En.—Endopodite.
13. Ep.—Epimera.
14. Ex.—Exopodite.
15. I.—Ischium.
16. Msp.—Marsupium.
17. Mdb.—Mandible.
18. Mdb. plp.—Mandibular palp.
19. Me.—Merus.
20. Mx.—I Maxilla.
21. Mx. II—II Maxilla.
22. Mxp.—Maxilliped.
23. P.—Penis.
24. Prt.—Protopodite.
25. Pro.—Propodus.
26. Pl.—Pleopod.
27. Pig. sp.—Pigmented spots.
28. Sp.—Spines.
29. T.—Telson.
30. Th.—Thorax.
31. Upd.—Uropod.
32. Q.M.P.—Quasi-molar-process.

# ON THE LARVAL STAGES OF IRONA FAR

BY

Mrs. J. G. ABRAHAM, M.Sc.

Though the adult of different species of *Irona* are described, the larval stages have not been described in detail so far. Schioedte and Meinert (1884) describe only the '*Pullus Stadii secundi*' of *I. renardi* and *I. nana* with figures of the larva and terminal segment of a typical peraeopod. In the description, the antennules are said to be eight jointed and antennæ nine jointed.

Hansen has recorded '*Pullus stadii primi*' of *I. foveolata* and has figured telson and uropods and second leg. The uropods are shown longer than telson with the outer rami longer than the inner rami unlike in the adult. No description is however given except that the young one at this stage is very similar to those of genus *Livoneca* drawn by Schioedte.

This is the first detailed description of both '*Pullus stadii primi*' and '*Pullus stadii secundi*' of any species of *Irona*. As both the stages of the larvae were found in large numbers in the marsupia of berried females of *I. far*, the larvæ as well as all the appendages have been drawn with the aid of camera Lucida and described in detail.

On the ventral side of the adult female is found a marsupium formed by four pairs of foliacious, striated white oostegites. This marsupium forms a cradle for the developing young. 225 to 400 larvae are found closely pressed and packed within each marsupium. Larvae of two stages were observed.

## LARVA OF I STAGE

*Colour and size.*—(Fig. 1) is light purple or greenish in colour with prominent black eyes. Numerous stellate pigment cells lie scattered all over the dorsal region of the larva. The tips of the claws are not pigmented. The pigmented areas at the bases of the dactili found in the adult are not observed at this stage. It ranges in length from 2·5 mm. to 3·75 mm.

| | *Length. Breadth.* |
|---|---|
| Size .. .. | 2·6 mm. × 0·9 mm. |
| Head .. .. | 0·3 mm. × 0·45 mm. |
| Thorax .. .. | 1·1 mm. × 0·9 mm. |
| Abdomen .. .. | 1·2 mm. × 0·5 mm. |
| Telson .. .. | 0·46 mm. × 0·4 mm. |

*General appearance.*—The larva as early as this stage looks *slightly asymmetrical* and probably indicates *the sex. The smallest larva is about 2·6 mm. long and 0·9 mm. wide at the broadest region of the body.* It is nearly thrice as long as broad. The *cephalon* is about one-fourth the length of the thorax and proportionately much larger than in the adult. It is nearly one and a half times broader than long and has a broad front anteriorly from which the antennal pairs are seen to spring. The eye is 0·25 mm. long with a diameter of 0·1 mm. granular, black, marginal and occupies the entire lateral margins of the cephalon behind the antennal pairs. The *thorax* is markedly wider than the abdomen which is nearly as long as the former but narrower. The relative length of the thoracic segments at this stage varies. The broadest region is that of the fourth and fifth and sixth segments. It is nearly twice as broad as the abdomen. The first six segments show a pair of appendages each while the last is without any as usual. The limbs are very slender, cylindrical and provided with simple straight claws whose tips are sharp. They are all similar, varying, only in size. The last thoracic segment is clear even in the earliest larva of the I stage and is slightly narrower than the preceding segment while it is broader than the abdominal segments.

The *abdomen* is markedly narrower than the thorax, and nearly as long as the thorax (1·2 mm. ×0·5 mm.). The first three segments are longer than the fourth and fifth and the posterior angles are more pronounced. The telson is well developed, shield shaped, with a broad anterior margin 0·5 mm. wide, while posteriorly it is narrower with a rounded tip. It is longer than broad. All the pleopods are similar. No sexual characters can be observed at this stage.

*Appendages—The Antennule.*—(Fig. 2) is eight-jointed as in adult, flat and broad and blunt tipped. All the joints except the last are short, roughly squarish and devoid of setules while the last is rounded distally and shows the rudiments of five to six aesthetases.

*The Antenna.*—(Fig. 2) is nine jointed and *much narrower and more delicate than the antennule* and tapers to a pointed tip. The fourth, fifth and sixth segments are longer than the rest. The tip carries the rudiments of four aesthetases.

*The Mandible.*—(Fig. 3). The bilobed quasi molar of the adult is not developed. The palp is thick, three-jointed, of which the second is the longest while the terminal is short with a rounded tip.

*The I Maxilla.*—(Fig. 4) is a simple appendage Unlike in the adult it is devoid of any spines or even rudiments of them.

*The II Maxilla.*—(Fig. 5) is bilobed. The outer lobe is much larger and longer than the inner. The teeth seen in the adult are not developed.

*The Maxilliped* (Fig. 6) is well developed, three-jointed and about 0·21 mm. long. The basal joint is the largest with a length of 0·11 mm. while the second is slightly shorter and 0·08 mm. long. The third is the shortest about 0·02 mm. long and shows at its summit a short conical tooth directed outwards. The other teeth have not yet appeared and this is the only difference from that of the adult.

*The I Thoracic appendage.*—(Fig. 7) is nearly 0·88 mm. long. Its claw is nearly as long as the propodus and is about 0·2 mm. in length. The *III limb* (Fig. 8) is longer than the first and is about 1·14 mm. long. The claw is stouter and stronger here, longer than the propodus and measures about 0·33 mm. The *last limb* VI pair (Fig. 9) is slightly shorther than the third and is about 1·08 mm. long. The claws are clearly marked from the limbs and are not curved. The segments are simple and devoid of spines or setules at this stage.

*A typical pleopod* (Fig. 10) at this stage is about 0·425 mm. long and has a distinct long protopodite 0·12 mms. × 0·09 mm. which is proportionately very much longer than in the adult. The rami are flat foliaceous and spring from a broad base. The exopodite is broader than the endopodite and measures 0·3 mm. × 0·15 mm. while the latter is narrower measuring nearly 0·31 mm. and 0·11 mm. Their margins particularly those of the exopodites are finely and microscopically wavy and devoid of setules. The *uropod* (Fig. 11) is 0·51 mm. long with a short thick basal protopodite 0·02 mm. × 0·125 mm. The exopodite and endopodite are longer than the telson and end in rounded tips. The exopodite is 0·31 mm. × 0·11 mm. and longer than the endopodite. The latter is 0·25 mm. × 0·12 mm. shorter but broader than the former. The spinous processes in the adult is not observed here. As in the pleopods, the margins of the rami are microscopically wavy indicating the rudiments of the formation of setules.

## LARVA OF II STAGE

Very soon this larva passes into the next stage. The larva of II stage differs from that of I stage in the following characteristics :—

(1) Size, colour, shape.

(2) Structure of cephalic appendages.

(3) Structure of few anterior thoracic appendages.

(4) That of abdominal appendages.

(5) In the development of statocyst in the exopodite of the uropod.

The larva (Fig. 12) is about 3·75 mm. long. The hitherto scattered pigment cells arrange themselves in transverse series along the anterior and posterior margins of the segments. It is faintly but distinctly striated at this stage. The larva is greyish in colour. The tips of the claw are not pigmented and the pigment dots at the bases of dactyli are also not recognisable even now.

Total length—3·75 mm. × 1·1 mm.

Head—0·5 mm. × 0·75 mm.

Thorax—1·5 mm. × 1·0 mm.

Total length abdomen—1·6 mm. × 0·8 mm.

Telson—0·6 mm. × 0·6 mm. and 0·05 mm. posteriorly.

*General appearance.*—The body has become narrower and more elongate so that the thorax looks slightly broader than the abdomen. The abdomen which was much narrower has become broader. The larva is about 3½ times longer than broad. The head is roughly semi-circular and the broad front has narrowed slightly and bent downwards. The eyes are 0·28 mm. long with a width of 0·25 mm. and have become rounded and occupy most of the mid lateral region of the cephalon. The anterior four thoracic segments are longer than the posterior three. Of the former, the third is the longest and about 0·33 mm. long. The broadest region is that of third and fourth segments. Of the three posterior segments, the last is the shortest. It is nearly as broad as the first pleon segment. The epimera are faint and flabby. The abdomen is not constricted from the thorax. The latter gradually continues as the broadabdomen which is 1·6 mm. without uropods and 1·8 mm. including the uropods. It is longer than the thorax. Telson is nearly as broad as long. There is no apical constriction here as is observed in *I. foveolata* (Hansen). The pleopods and uropods are microscopically fringed with long setules.

*Appendages.—Antennules* (Fig. 13) is nearly 0·47mm. long. It has not increased in length but is very different in structure. The three basal segments which are square have become 0·075 mm. long and are the longest. The fourth and fifth segments though smaller than the former is stouter than the sixth. The sixth seventh and eighth are elongate, and narrower than the rest (0·017 mm. diameter). The distal segment is very elongate and ends in a rounded tip and carries two aesthestase setae. Of these the posterior is longer and 0·085 mm. long while the anterior is shorter and only 0·065 mm. long. The distal anterior margin of the sixth segment carries 2 short aesthestase setules while that of seventh carries one. The distal segment has become very finely delicate in this stage. The segments have become much narrower, elongate and setose and very different from that of the I stage larva where they are stout flat and stumpy.

The *Antenna* (Fig. 14) has become comparatively longer and larger in size. From 0·5 mm. it has grown to 0·6 mm. long. Here the segments do not show any difference in the general shape as in the antennules. All the segments are more or less rectangular and elongate. The fifth and sixth are the largest and have a diameter of 0·058 mm. and the eighth is the shortest while the ninth is conical, fine tipped and ends in a tuft of five to six aesthestases. The appendage is 0·05 mm. thick at the base and 0·015 mm. at its tip. The fifth segment bears one asthestase setae in the distal anterior margin and three such at the inner margin. The sixth and eighth segments bear one and two such setae in their distal anterior margin. Ordinary setae are not found in any of the segments. Such specialized setae are said to be associated with the sense of smell and occur in the antennules and often in the antennae of most crustacea. [Lankester (1909)]. The cuticle here is extremely delicate. These are slender and tubular showing a partician in the middle when they are long. In the shorter tufts such particians are not conspicuously observed.

The *Mandible* (Fig. 15) is 0·36 mm. long including the setules of the palp which is nearly 0·25 mm. long. The segments of the palp are narrower than those of the I stage. The protopodite has become longer and is about 0·9 mm. long. The distal region of the protopodite which was simple, rounded and setose has become expanded and modified into a quasi molar like process much like that of the adult. The anterior tooth of the process is not brown as in the adult. I *maxilla* (Fig. 16) is about 0·18 mm. long and 0 032 mm. at the base and 0·0175 mm. at the tip. At this stage it shows four more or less similar conical sharp teeth as in the adult. The teeth are about 0·016 mm. long. II *maxilla* (Fig. 17) is about 0·175 mm. long and 0·015 mm. broad at the base. Distally it is slightly narrower. The plain lobes of the larva of I stage now show four conical spines 0·0175 mm. long in each lobe distally as in the adult. They are not located as four sets of spines. Most probably the differentiation and location of these spines take place at a still later stage. The *maxilliped* (Fig. 18) is nearly 0·28 mm. long and 0·08 mm. broad at the base. The basal segment is rectangular, larger and measures 0·135 mm. × 0·08 mm. The second is slightly shorter than the first but as broad as that segment and measures 0·11 mm. × 0·08 mm.

The distal segment is the shortest, conical measuring 0·035 mm. × 0·0175 mm. and shows at its summit three outwardly directed curved teeth. The fourth one at the base has not developed yet. The teeth are nearly equidistant from one another.

The six pairs of thoracic appendages at this stage show a marked increase in length and size. The first three pairs differ much from the last three pairs and show very elongate, curved and toothed dactyli and are thus best adapted for clinging to a suitable host. The structure and number of these teeth are variable. The propodus of all the appendages show three short strong spines at their inner margins while the carpals of second to seventh also show one short spine each. The I *thoracic leg* (Fig. 19) has grown to about 1·1 mm. long. The claw is 0·31 mm. long and carries nine to eleven short conical teeth at its basal inner margin. The tip is plain and long and used for clinging. The merus and carpus are nearly equal and short. The propodus at its inner margin shows three conical spines. The III *thoracic leg* (Fig. 20) is about 1·3 mm. long and longer than the first. The basis is much enlarged here while the merus is more elongate than the first pair and is as long as the *Ischium*. The carpus is the shortest segment and unlike in the first carries a tooth at its anterior inner margin. As in the first, the propodus is nealry as long as the basis and bears three spines at its inner margin. The dactylus is much longer, is 0·38mm. long, is greatly curved and shows about eleven to thirteen longer conical teeth. The free tip of the dactylus is also comparatively longer here. The second pairs are similar in structure and present the following characteristics. *Last thoracic leg* (Fig. 21) is about 1·19 mm. long and is slightly shorter than the third leg. As in the first pair, the merus and carpus are short and equal in length. The carpus carries a spine at its inner margin. The propodus as in all carries three spines. The dactylus is 0·28 mm. shorter than those of the anterior pairs and more curved but simple as in the larva of the I stage. The pleopods are all similar but are much different from those of the I stage larvae.

A typical pleopod (Fig. 22) is nearly 0·48 mm. long. The protopodite is differentiated into coxopodite and basipodite, is broader than long measuring o·175 mm.×0·2mm. The proximal segment, coxopodite is much shorter and slightly narrower than the distal basipodite and is 0·065 mm long and 0·16 mm. broad. The distal basipodite is twice as broad as long 0·2 mms.×0·1 mm. and is modified for swimming. The inner distal margin of the basipodite carries a tuft of coupling hooks (retinacula) (Fig. 22) Each retinacula consists of four simple long curved hooks directed backwards and outwards measuring about 0·06 mm and a longer pinnate setule 0·8 mm. long. These hooks are used in coupling together the appendages of each pair so that they can work forwards and backwards efficiently as paddles. Such retinacula have been observed from some adult free-swimming isopods. Here retinacula are absent in the adult. The exopodite is 0·3 mm. × 0·18 mm. broader than the endopodite with a narrow distal end. The endopodite is 0·29 mm.×0·14 mm. is slightly narrower than the exo and broader at its distal end. The free distal margins of both the rami are fringed with long, pinnate setules of about 0·07 mm. length. The outer margin of the endopodite which is overlapped by the exopodite is devoid of setules while, that of the exopodite is setose to nearly half its length from the base. The basal inner margin of the endopodite shows a number of small simple setules. . Perhaps these also aid in coupling the appendages together. Both the rami serve as respiratory and natatory organs. The latter function is indicated by the marginal setae and the presence of group of coupling hooks on the inner margin. The *uropods* (Fig. 23) shows a marked change. These also are fringed with pinnate setules but their position differs. Each is about 0·75 mm. long, and the protopodite measures 0·29 mms. × 0·15 mm. The exopodite is 0·4 mm. and 0·13 mm. broad while the endopodite is 0·27 mm.×0·14 mm. and shorter and broader than the former. Unlike the pleopods the outer margin of the endopodite overlapped by the exopodite is fringed with pinnate setules.

The entire outer margin of the exopodite is smooth and non setose while three-fourths of the inner margin from the distal end is fringed with pinnate setae ranging from 0·09 mm. to 0·12 mm. in length. At the distal margin of the exopodite, outer to the pinnate setules, two long sharp simple spines are observed of which outer is short and 0·05 mm. long while the inner is longer and about 0·07 mm. long. The occurrence is interesting and their function is not known. Two such spines are said to occur in the larva of I. *nana* and one in I. *renardi*. Another interesting feature is the occurrence of an oval statocyst. 0·15 mm. ×0·1 mm. in the middle of the exopodite. A few muscles are seen to pass from the inner wall, towards the centre and seem to support a statolith mass. In *Anthura gracilis* and a species of *Anthuridae, Thielmann* has described statocyst in the anterior part of telson. These are the only isopods where statocysts have been observed. To my knowledge no statocysts have ever been observed in any of the larval stages. This is of great interest. The entire structure and development of the statocyst in the embryology of I. far will be dealt with in detail in due course.

The mouth parts of the larvae have become adapted for biting and sucking like those of the adult. Olfactory setules and statocysts are developed. The thoracic limbs specially the anterior three pairs are best adapted for clinging and attachment. The pleopods and uropods are fringed with pinnate setules and coupling hooks. Thus the larva of II stage is well adapted for a free swimming life. These larvae are supposed to leave the marsupuim before the development of the last thoracic limbs. An attempt is being made to investigate the complete life history of this parasitic isopod.

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## EXPLANATION OF FIGURES.

| | | |
|---|---|---|
| 1 | Larva of first stage | x 40 |
| 2 | The antennal pairs | x280 |
| 3 | Mandible | x280 |
| 4 | I. maxilla and labrum | x280 |
| 5 | II. maxilla | x280 |
| 6 | Maxilliped | x280 |
| 7 | First thoracic leg | x280 |
| 8 | Third thoracic leg | x280 |
| 9 | Sixth thoracic leg | x280 |
| 10 | A pleopod | x200 |
| 11 | The uropod | x200 |
| 12 | Larva of II stage | x 40 |
| 13 | I antenna | x280 |
| 14 | II antenna | x280 |
| 15 | Mandible showing quasimolar process | x280 |
| 16 | I maxilla | x280 |
| 17 | II maxilla | x280 |
| 18 | Maxilliped | x280 |
| 19 | First thoracic leg | x 80 |
| 20 | Third thoracic leg | x 80 |
| 21 | Sixth thoracic leg | x 80 |
| 22 | A pleopod | x200 |
| 23 | Uropod | x200 |

## KEY TO LETTERING.

1 A—Antennule.
2 Ab.—Abdomen.
3 Ant.—Antenna.
4 Aesth.—Aesthestase.
5 B.—Basis.
6 C.—Cephalon.
7 Cl.—Claw.
8 Ca.—Carpus.
9 D.—Dactylus.
10 E.—Eye.
11 En.—Endopodite.
12 Ex.—Exopodite.
13 I.—Ischium.
14 L.—Labrum.
15 Me.—Merus.
16 Prt.—Protopodite.
17 Prp.—Propodus.
18 Pl.—Pleopod.
19 P.S.—Pinnate setule.
20 Rte.—Retinacula.
21 Sp.—Spines.
22 St.—Statocyst.
23 T.—Telson.
24 Te.—Teeth.
25 Th.—Thorax.
26 Upd.—Uropod.

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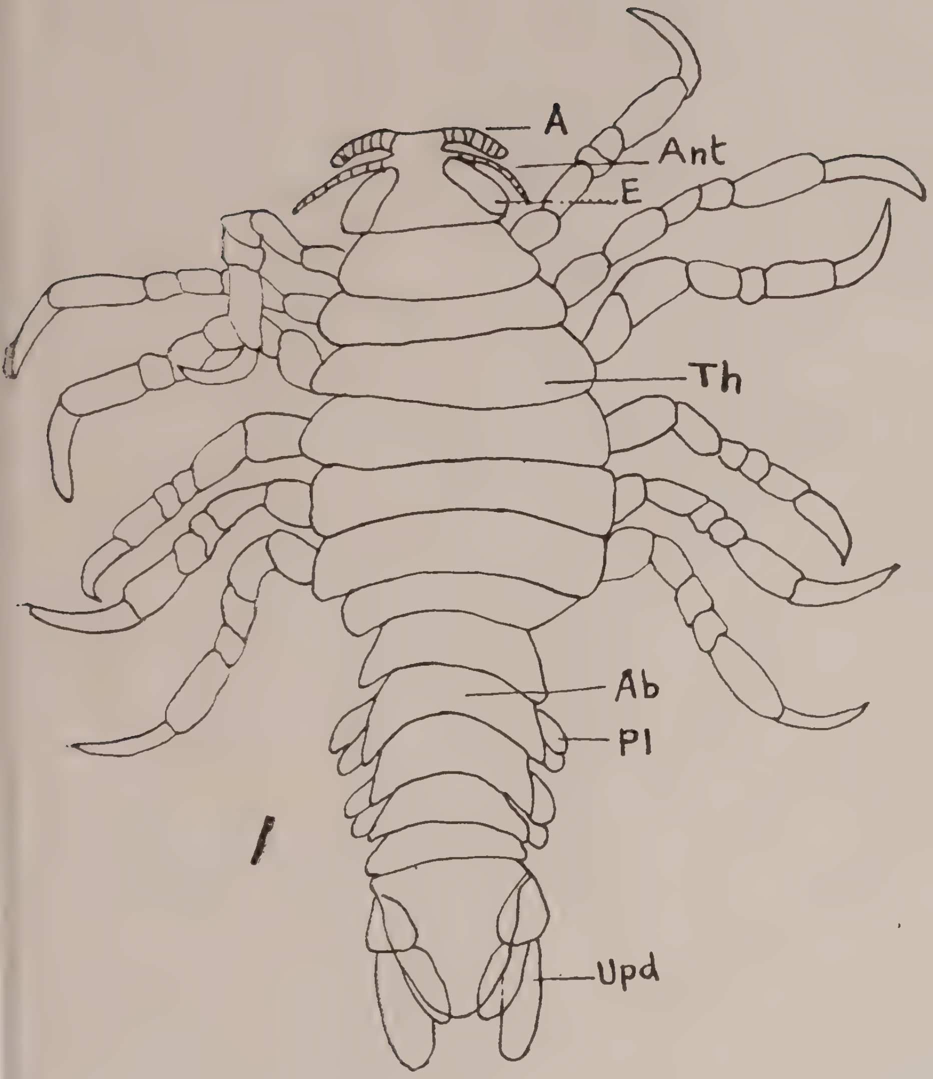

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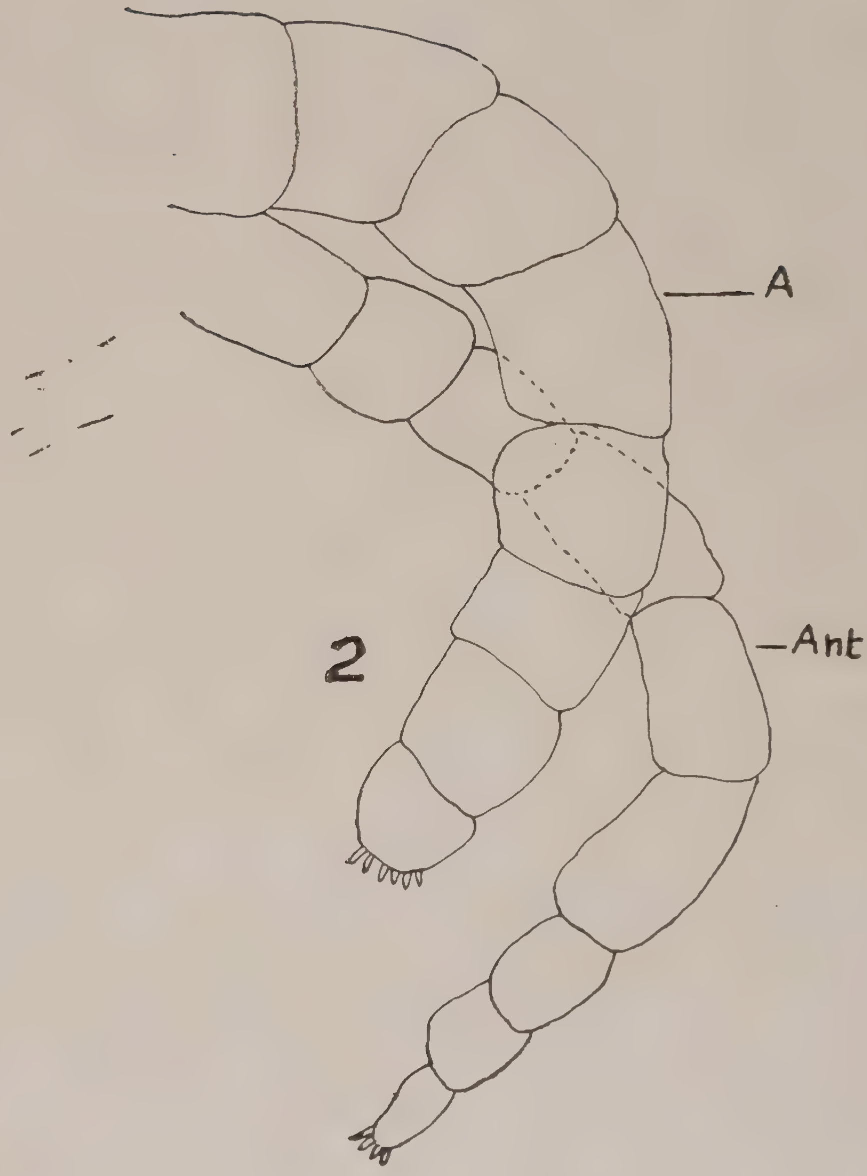

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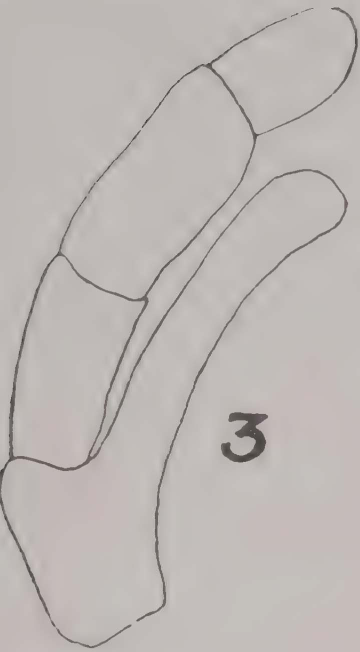
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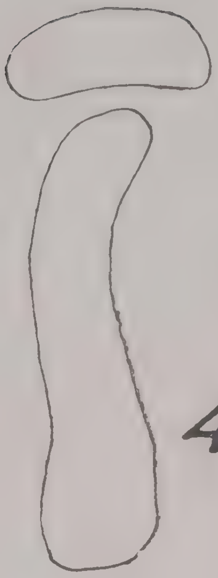
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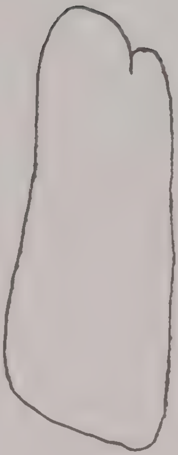
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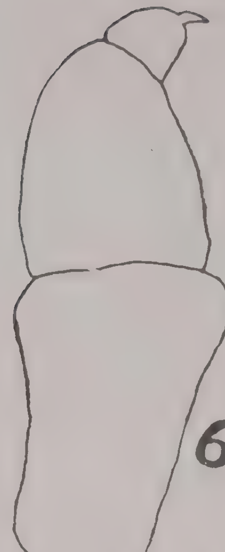
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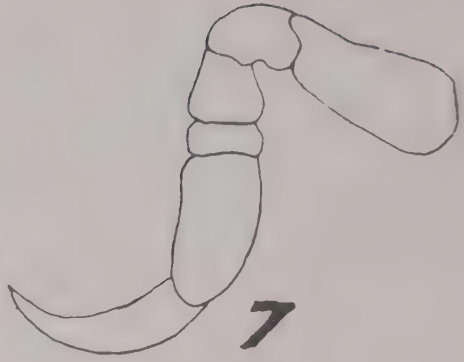
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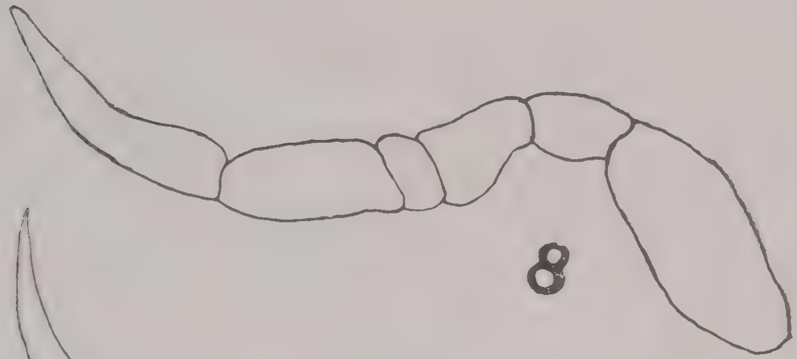
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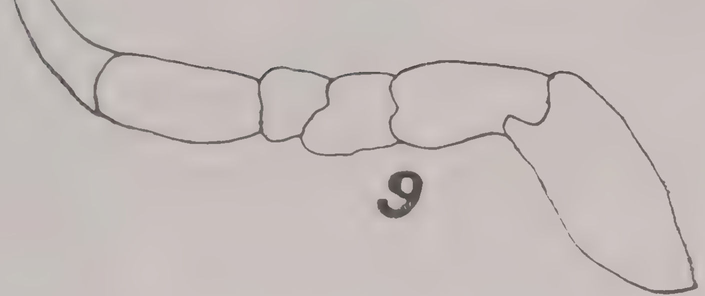
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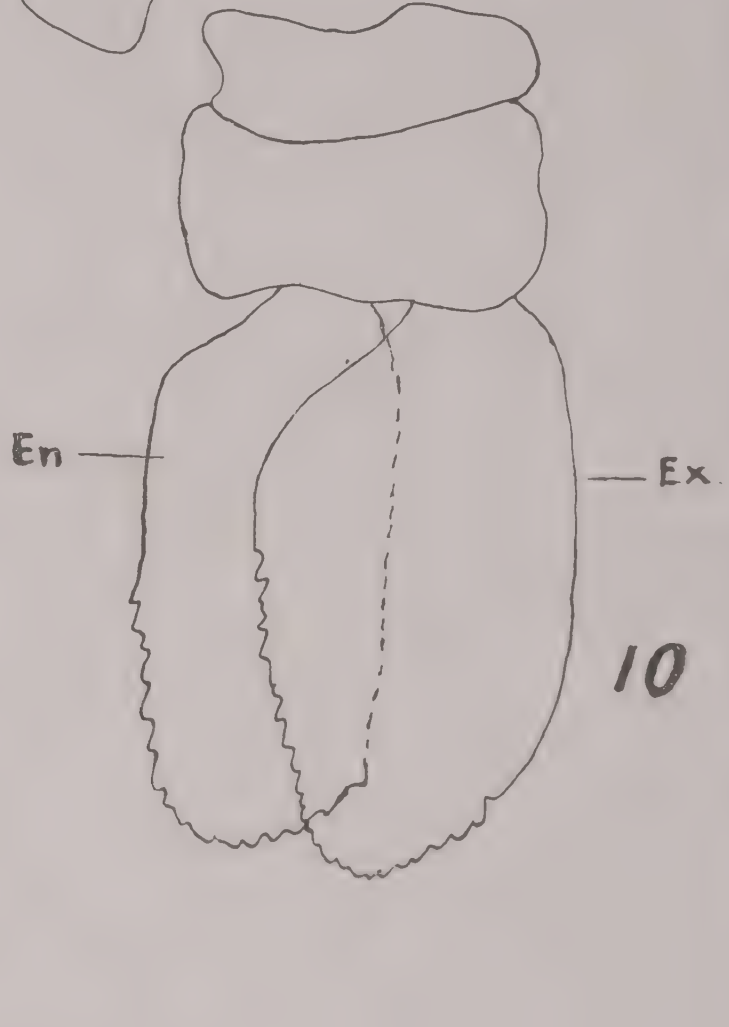

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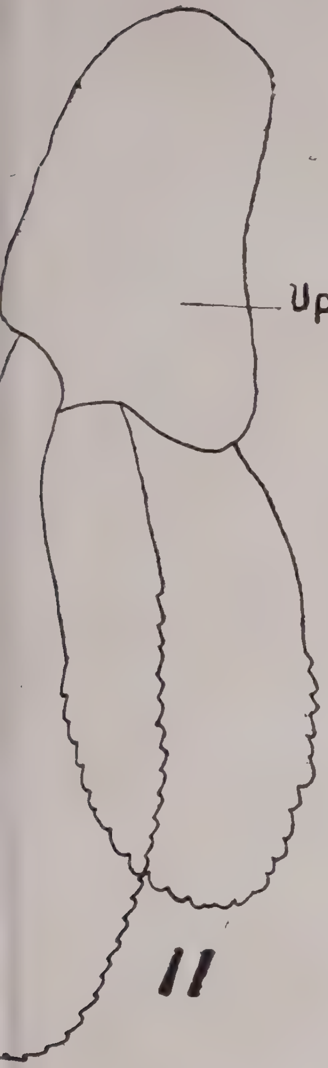

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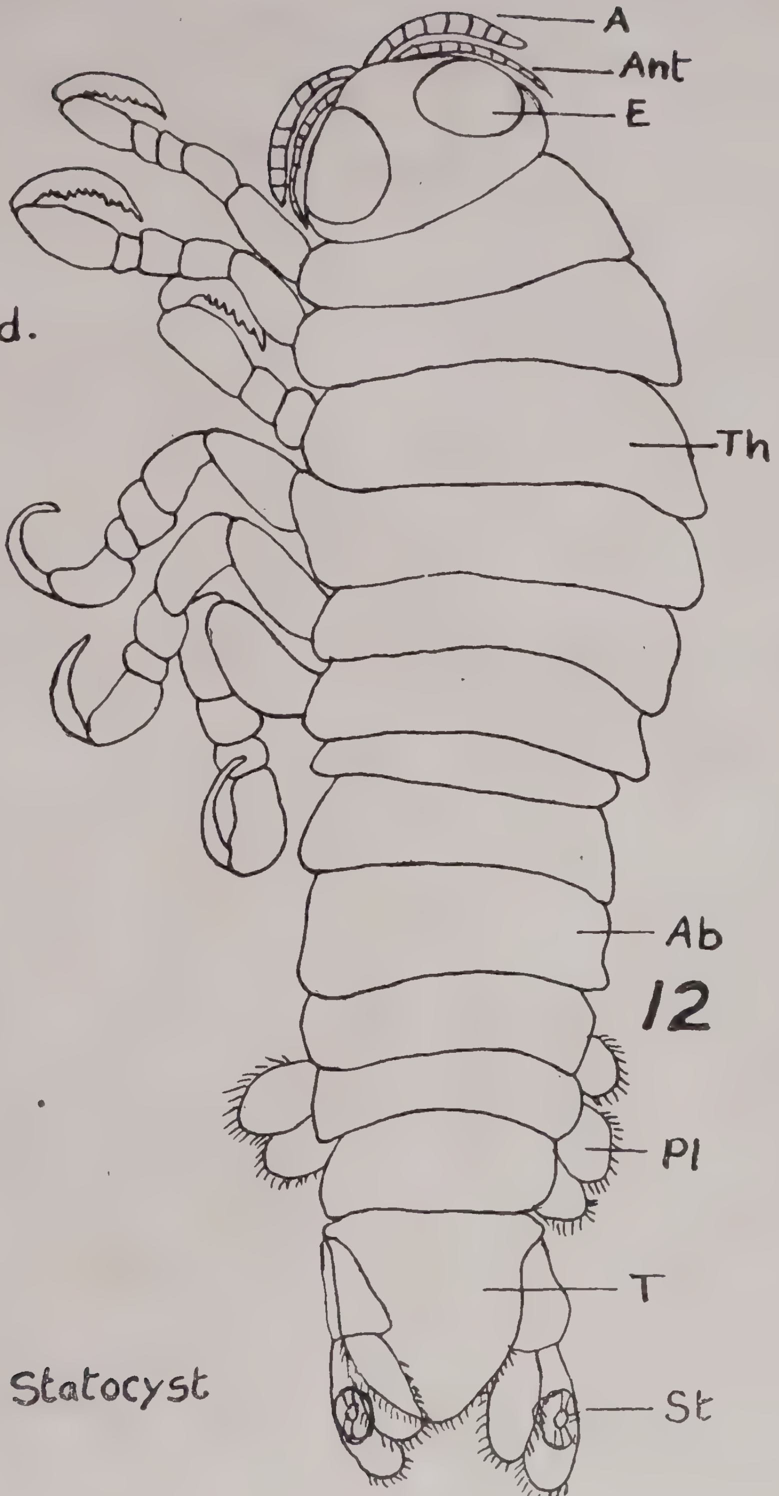

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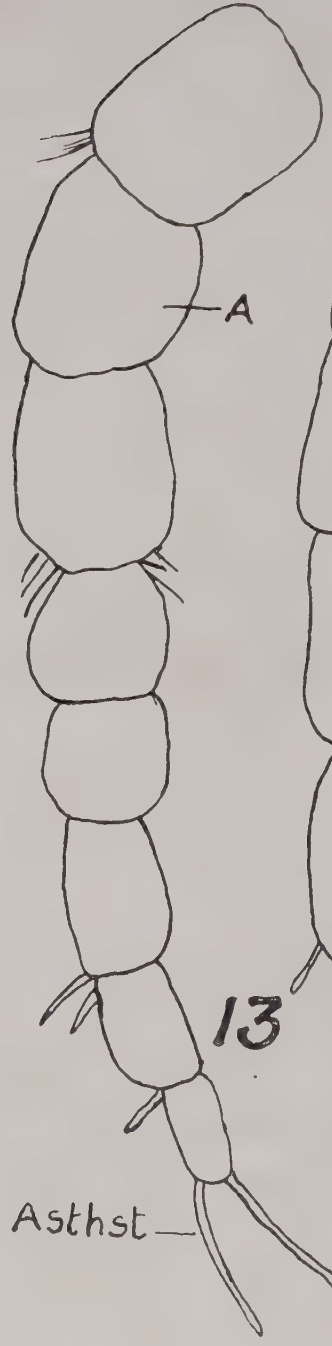

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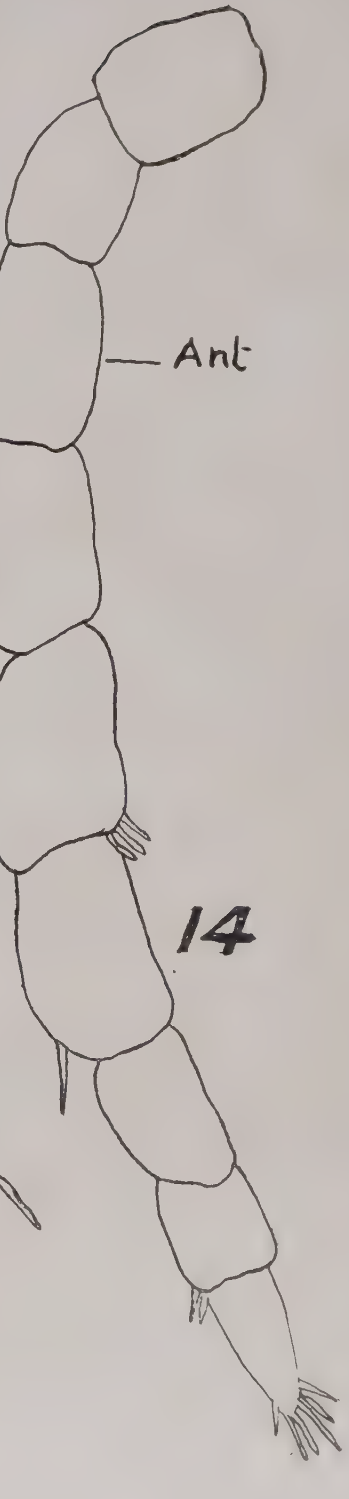

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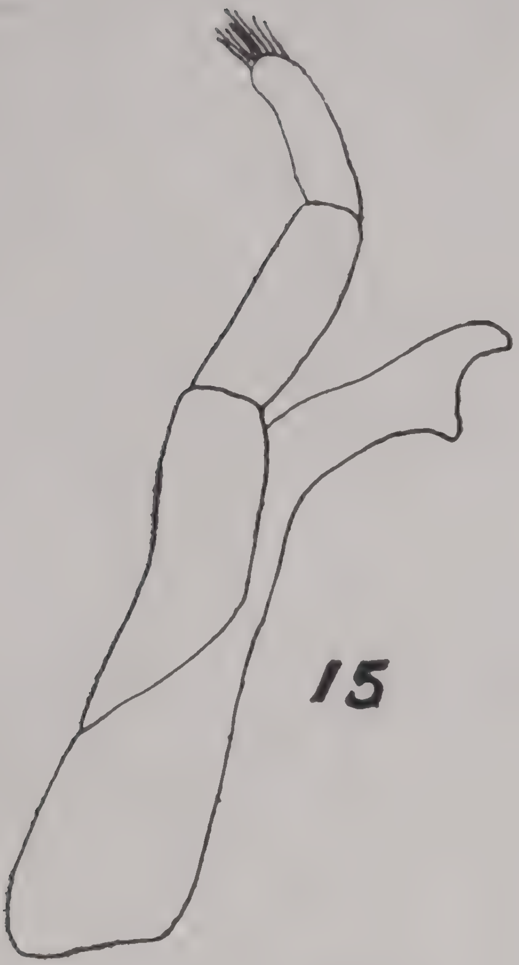

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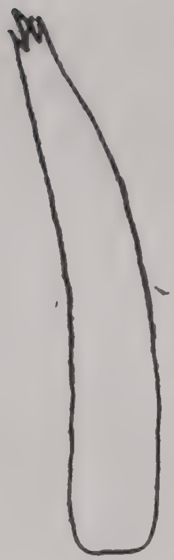

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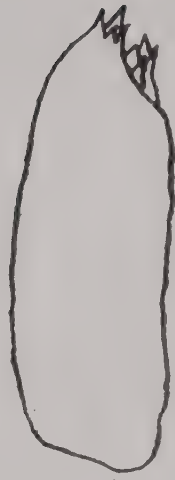

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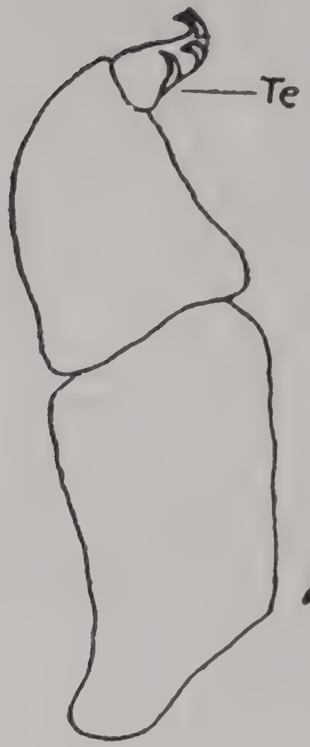

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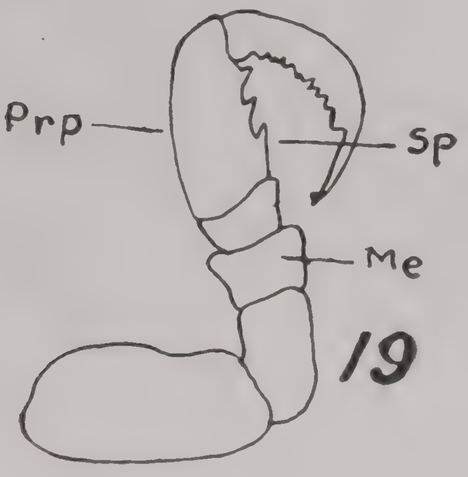

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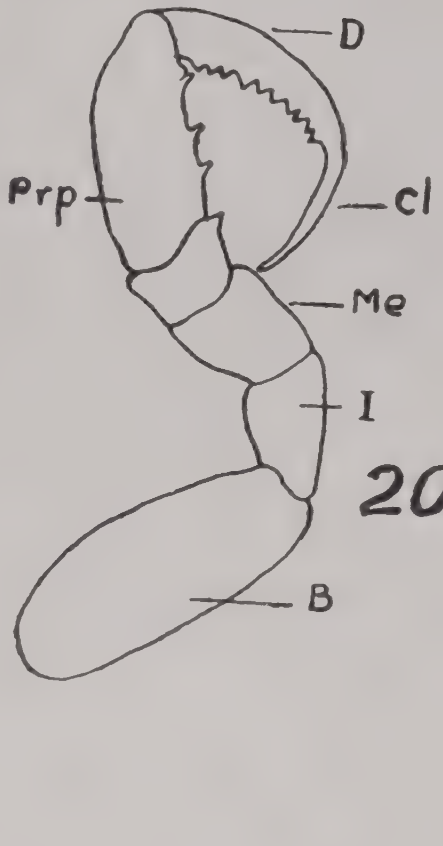

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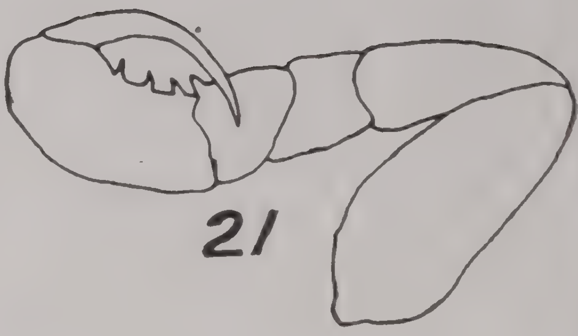

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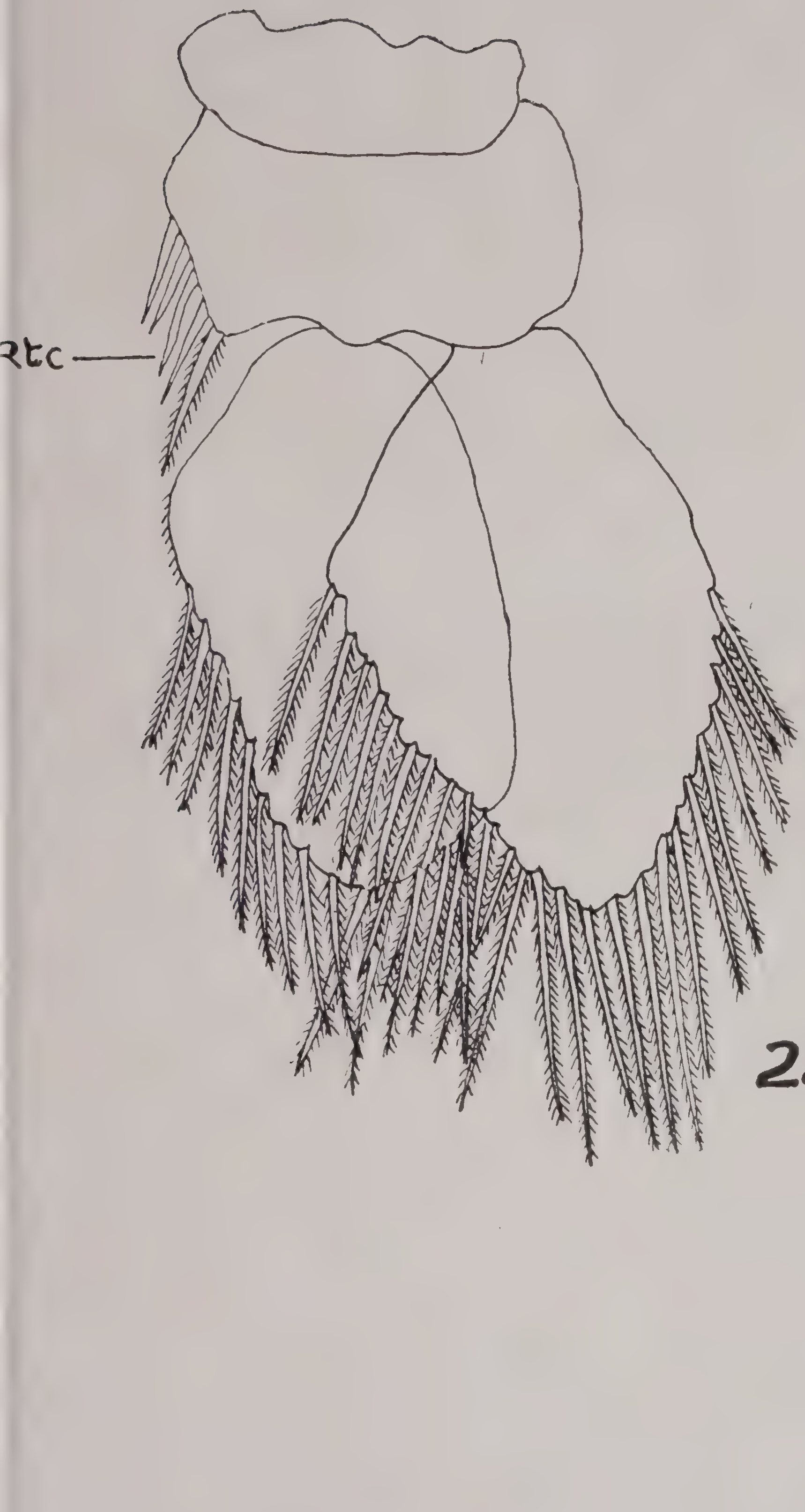

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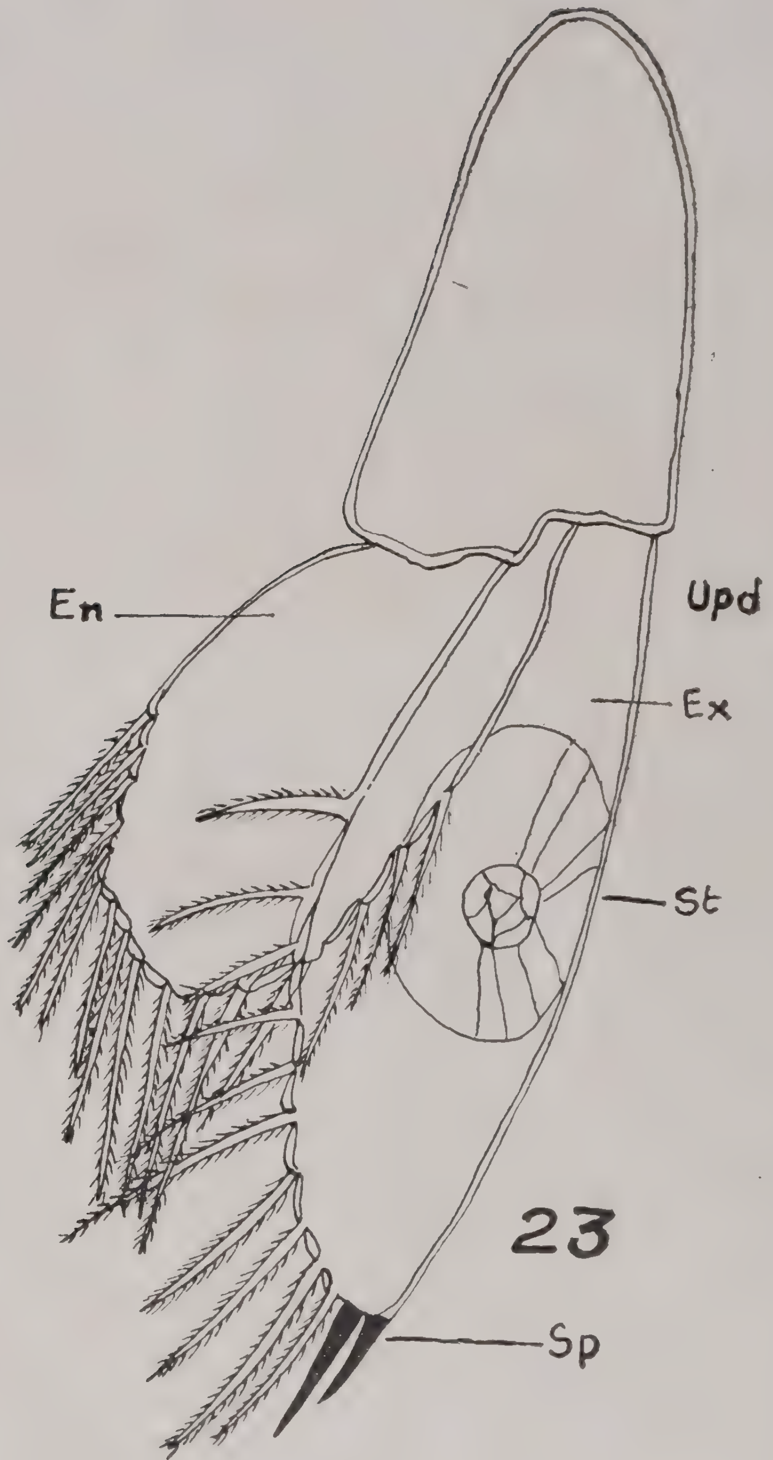

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# PRELIMINARY NOTE ON THE BIONOMICS AND FISHERIES OF THE GIZZARD SHAD, CHATOESSUS NASUS IN ENNORE AND PULICAT BACKWATERS

BY

P. I. CHACKO, A. RAJAGOPAL AND P. MOHANAKRISHNAN.

The gizzard shad, *Chatoessus nasus* contributes to moderate fisheries in the backwaters of Ennore and Pulicat. Statistics of landings of this fish during the triennium, 1959–60, 1960–61 and 1961–62 are given in Table I. The annual catch varied from 8,186 to 19,464 pounds in the Ennore backwater and from 19,939 to 44,829 pounds in the Pulicat backwater. Whereas the fishery has doubled in Ennore it has declined by more than 50 per cent in Pulicat.

Material for this investigation was obtained mostly from Ennore creek and few samples from Pulicat lake. Almost all the specimens were examined in the fresh condition itself, a few being preserved in 5 per cent formalin and examined at a convenient time later. During the period of investigation (1959–1962) a total number of 677 fishes were examined and their standard lengths were taken according to the usually accepted method, namely, from the tip of the snout, when the mouth is closed to the base of the hypurals.

There is difference in the length-weight relationship of male and female individuals. The rate of increase in weight by the fish is little as the fish grows in length up to 110 mm. Then the female fish starts to gain weight up to 180 mm. with a brief pause between 140 and 150 mm. The increase in weight is more rapid after 180 mm. In the case of male, it gains in weight when it reaches a length of 120 mm. and up to 140 mm. There is a pause for the next 10 mm. length and thereafter it begins to gain in weight but not so fast as in the female. Throughout the investigation fishes of the length group, 80 to 120 mm. occured in majority. Fish of length more than 190 mm. are rare. The minimum and maximum size of fish examined is 62 mm. and 229 mm. respectively. The maximum weight attained by the fish is 313 gm.

According to the available material both male and female start breeding when 120-140 mm. in length and spawns when 170 mm. in size. There is a second spawning when 230 mm. in size.

The fish is omnivorous in its feeding. Sand grains were found invariably indicating browsing at the bottom. But mostly it feeds at midwater and consumes what small organisms that come in their way. The following were noted in the stomach contents examined :—

(*a*) *Diatoms* :—*Asterionella, Bacillaria, Biddulphia, Chaetoceras, Coscinodiscus, Navicula, Nitzschia, Pleurosigma,* and *Rhizosolenia.*

(*b*) *Filamentous green algae* :—*Spirogyra.*

(*c*) *Blue-green algae* :—*Oscillatoria.*

(*d*) *Protozoa* :—Foramminiferan shells, *Tintinnus* and *Peridinium.*

(*e*) *Coelenterata* :—Small medusae (rarely).

(*f*) *Annelida* :—Polychaete larva of *Tomopterus.*

(*g*) *Mollusca* :—Larval bivalves and larval gastropods.

(*h*) *Crustacea* :—Copepods, Nauplii larvae, Mysis, Zoea, amphipods and young prawns.

(*i*) *Miscellaneous* :—Organic debris and sand grains.

The fish is caught with stringless cast net (operated by one person), Siruvalai (5 persons), Thattu valai or Oei Valai (10 persons), Konda valai (2 persons), rod and line and occasionally with gill net. Operation of siru valai and thattu valai yields good catches. When the water level is high during flood season another fishing net called Kattu valai (stake net) is operated.

Daily catches are transported to Madras City markets and sold to the public in the fresh conditions.

Three parasitic isopods are found to attack the fish. They are *Cymathoa, Anilocra* and *Cerolina.* They are found in the gill region and eat away the gill filaments of the fish.

TABLE I

*Showing weight of* Chatoessus nasus *landed at Ennore and Pulicat backwaters in* 1959–62 (*Pounds*).

| *Month.* | *Ennore backwaters.* | | | *Pulicat backwaters.* | | |
|---|---|---|---|---|---|---|
| | 1959–60. | 1960–61. | 1961–62. | 1959–60. | 1960–61. | 1961–62. |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| April .. .. .. .. | 563 | 2,949 | 3,367 | 2,540 | 2,994 | 3,084 |
| May .. .. .. .. | 709 | 2,166 | 1,110 | 3,829 | 3,084 | .. |
| June .. .. .. .. | 1,070 | 192 | 1,223 | 2,803 | 4,535 | 1,814 |
| July .. .. .. .. | 1,163 | 1,348 | 3,412 | 4,192 | 3,357 | 1,089 |
| August .. .. .. .. | 1,318 | 2,448 | 3,548 | 3,246 | 2,722 | 1,905 |
| September .. .. .. .. | 1,045 | 2,127 | 276 | 3,829 | 1,361 | 1,814 |
| October .. .. .. .. | 757 | 1,017 | 790 | 12,338 | 726 | 1,361 |
| November .. .. .. .. | 2,139 | .. | 840 | 9,516 | .. | 3,348 |
| December .. .. .. .. | 46 | 590 | 757 | 1,348 | 3,985 | .. |
| January .. .. .. .. | 21 | 1,352 | 1,208 | .. | 3,357 | .. |
| February .. .. .. .. | 258 | 68 | 1,873 | .. | 2,250 | 3,265 |
| March .. .. .. .. | 297 | 1,072 | 1,060 | 1,179 | 3,010 | 2,259 |
| Total .. | 8,186 | 15,429 | 19,464 | 44,820 | 38,381 | 19,939 |

# FOOD AND FEEDING HABITS OF PERCHES OF TUTICORIN COAST, GULF OF MANNAR

BY

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A preliminary study of the stomach contents of some fishes obtained during survey of the pearl bank Thollayiram par, in 1954 and 1955 was made by Chacko (1959). He found pearl oyster shells in three specimens of *Abalistes stellaris* and suggested that more investigations should be undertaken to ascertain the food and feeding habits of the fishes of pearl banks and their inter-relationships. Chacko and Rajendran (1956) cited the importance of perch fishery in Tuticorin, and indicated the important fishing grounds of these perches in the vicinity of the pearl banks. With a view to continue the work on food and feeding habits of fishes of the pearl banks and to acertain the role played by the perch, *Lethrinus* (Velameen) which has been found by Herdman (1957) to feed upon immature oysters, the present investigation was taken up in 1957.

The stomachs of perches were collected from landing place where the fishermen gut the fishes for salting and curing. The samples were then preserved each separately with a label indicating the date, species and length of the fish. Stomachs of *Serranus undulosus*, and *Lethrinus nebulosus* were obtained in larger numbers than that of other perches. The food was analysed quantitatively and qualitatively for six months from June to November 1957. No definite conclusions could be arrived at beyond indicating certain possibilities, as such work based on small number and within a short period has its own limitations.

## RESULTS

I. *Serranus undulosus.* (Local name: *Kalawa*). This fish is common in the catches of fishermen. Ninety stomachs were examined out ofwhich fifty-four were found empty. The length of fishes varied from 30 cm. to 90 cm. The organisms present and their percentage are shown in Table I below in the descending order of percentage.

Table I.

| *Serial number and name of ingredient in stomach.* | *Percentage.* |
|---|---|
| 1 Sardines .. .. .. .. .. | 51·40 |
| 2 *Leiognathus* .. .. .. .. .. | 25·22 |
| 3 Miscellaneous parts of fish .. .. | 9·60 |
| 4 Crabs .. .. .. .. .. | 6·00 |
| 5 Prawns .. .. .. .. .. | 3·10 |
| 6 Sand grains .. .. .. .. | 2·18 |
| 7 Young *Saurida tumbil* .. .. .. | 1·30 |
| 8 Other miscellaneous items .. .. | 0·95 |
| 9 Fish scales .. .. .. .. .. | 0 25 |

From the above table it is seen that *Serranus undulosus* feeds mostly on fish which forms 87·77 per cent of the total ingredients, of which nearly ~~51~~·40 per cent is composed of sardines. Crustaceans contribute to 9·10 per cent and hence form only a minor item of food. The presence of sand grains 2·18 per cent indicate occasional bottom feeding habits. Though pearl oysters have not been noticed in the stomach contents, the bottom feeding habits of the fish indicate that they might occasionally feed upon organisms such as young pearl oysters also occurring at the bottom.

II. *Lethrinus nebulosus*—(Local name: *Velameen*).—This fish is also common in the catches of the local fishermen. Eighty-nine stomachs were examined of which thirty were found to be empty. The length of the fish varied from 24 to 95 cms. The organisms present and their percentage are shown in Table 2 below in the descending order of percentage.

Table II.

| *Serial number and name of ingredient in stomach.* | *Percentage.* |
|---|---|
| 1 Sardines .. .. .. .. .. | 38·56 |
| 2 Other fishes .. .. .. .. | 31·40 |
| 3 Flat fishes (*Pleuronectidae*) .. .. | 8·54 |
| 4 Pearl oyster shells, flesh and young oysters. | 7·70 |
| 5 Crabs and appendages .. .. .. | 6·44 |
| 6 Prawns .. .. .. .. .. | 3·30 |
| 7 *Echinoidea* (Sea urchins and Clypeaster). | 1·80 |
| 8 Algal matter .. .. .. | 1·30 |
| 9 Bivavle shells, sand grains, fish scales, etc. | 0·76 |
| 10 Polycheate worms .. .. .. .. | 0·20 |

It is seen that *Lethrinus nebulosus* feed mostly on fishes which forms 78·50 per cent of their stomach contents, crustacians form 9·74 per cent and pearl oysters 7·70 per cent, the other food items being of minor importance. This fish feeds at the sea bottom on the fauna and flora there as indicated by the presence of flat fishes, pearl oysters, seaurchins, clypeaster, algal matter, bivalve shells, polychaete worms and sand grains. *Lethrinus nebulosus* feeds mostly on fishes but is a potential enemy to pearl oysters. This requires further observations.

III. *Aprion pristipoma*—(Local name: *Lomia*).—Out of the twenty-six stomachs examined twenty four were empty. The remaining two contained only a small percentage of sand grains. The length of the fishes varied from 31 cm. to 81 cm.

IV. *Serranus salmoides*—(Local name: *Pandari*).—Out of the thirteen stomachs examined eight were empty. The remaining five contained sardines, exoskeleton of crabs, mytilus shells and sand grains. The length of the fishes varied from 40 to 100 cm.

V. *Lutjanus malabaricus*—(Local name: *Kuruvalai*).—The two stomachs examined contained, flesh of fish, gastropod shells, appendages of crabs, vertebrae of fish and sand grains. The fishes measured 51·4 cm. and 96·4 cm.

VI. *Lates calcarifer*—(Local name: *Koduwa*).—The single stomach examined of the fish of 54 cm. in size, contained one prawn 7 cm. in length.

## ACKNOWLEDGEMENTS

I am thankful to Sri P. I. Chacko, Assistant Director of Fisheries, Information and Marine Biology, for guidance.

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# MURREL CULTURE AS A COMMERCIAL FISHERY IN MADRAS STATE

BY

SRI T. M. ARUMUGAM, M.A.

" Murrel " is the popular name given to the bony fishes belonging to the piscine group '*ophiocephalidae*'. The latin nomenclature '*ophiocephalus*' means snake headed fish (ophis=snake, cephalus=head). Bloch so named the genus owing to the heads of these having a resemblance to those of serpents. The scales on the head are enlarged and thickened resembling the shields (plates on the head) of a snake unlike those on the body which are of the normal cycloid type.

## SHAPE

The body of murrel is elongated and sub-cylindrical anteriorly, i.e., the head is flat. Eyes are lateral. Gill openings are wide, the membrane of the two sides being connected beneath the isthmus. There are enlarged and pointed teeth in the jaws giving a very good grip for the fish to hold on to the prey firmly when caught in its mouth. A cavity exists above the true gill chamber called supra-branchial cavity, in which bony laminae tinged with blood vessels, are present. These serve as air sacs for the fishes to breathe when out of water. Due to such an amphibious mode of respiration, the murrel is able to live for lengthened period out of its natural element, i.e., water.

It has a single, long spineless dorsal fin and a similar but shorter anal fin, a more or less circular caudal fin and a thoracic ventral fin. Due to the breadth of its body, the murrel is able to progress in a serpentine manner on ground, chiefly by means of its pectorals and caudal, first one of the former being advanced and then its fellow alternatively. Due to the capacity of this fish to live outside water, to breathe atmospheric air and to move or crawl to a certain distance on ground when moist, some jugglers in China and India, exhibit these fishes walking on the land amusing the onlookers and thereby earn some money. The murrels secrete a lot of slime over their body like eels but not to such a great extent, so that these escape by being slippery while being caught in hand.

## DISTRIBUTION

Murrels are freshwater fishes distributed through out India, Burma, Ceylon and the East from elevated localities and the most Inland Districts, to within the influence of the tides. They inhabit both the ponds and rivers and are able to change their place of abode by traversing moist pieces of ground intervening between one piece of water and another. When tanks dry up, these fishes get buried in the slush and hibernate. With the onset of rain these become active again which make some Indian rural folk erroneously to consider them as having descended with the downpour of rain.

*O. striatus* and *O. punctatus* are very commonly found in ditches, ponds, reservoirs while *O. marulius* are found in rivers where it prefers deeper sections with sandy bottom and submerged rocks. *O. gachua* occurs mostly in rivers than ponds and frequents backwaters with tidal influence.

Generally murrels living in tanks and swamps, delight in basking at the shallow and grassy edges so that they can take in with ease the atmospheric air for purpose of breathing and at the same time capture any prey like frogs, tadpoles, etc., that may uncautiously come close to their lair. Murrels prefer dirty to clean water, perhaps for purposes of hiding. Periodically they stir up the sediment and secrete a quantity of mucus when they appear to be delighted, their colours become quite vivid and then they take to other favourite resort just beneath the surface of the water amongst the weedy margins. When the water becomes settled and clear, it becomes excited and change their resort.

## ECONOMIC IMPORTANCE

Murrels are ranked highly with the carps in Bengal. In Punjab, these are regarded as an excellent food fish. In South India, murrels are sought after as a delicious freshwater food fish. In Burma, Telaings consider the variety, ophiocephalus striatus (Day) as efficacious in cases of sickness. When a person is sick, they purchase a big sized fish of O. striatus, a rope is inserted by the sick through its nostrils like bullock and a group of relatives of the sick gather round it, dragging it round and round to propitiate the offended spirit causing sickness to the individual. Then the fish is offered to the spirit. This religious ceremony is said to remove the illness from the sick man.

The river murrel, *O. marulius*, is not relished in some parts of Bengal and Burma. In the lower parts of Bengal, people abstain from eating this variety on religious grounds. Karens in Burma think that these fishes were formerly men, changed into fish for their sins and so they believe that men eating these fishes, will be transformed into lions (Mason).

The flesh of the fish living in streams and rivers tastes better than those bredinponds, the latter having a muddy flavour. The murrel unlike other freshwater fishes, has a single vertebral column to be reckoned with in the cooked stage and offers safer and delicious culinary effect on its consumers. The flesh of this fish is also not so soft as that of carps and on cooking gives an agreeable flavour. The fish gives better taste when sauce is made with it than when fried.

## CLASSIFICATION

The different species are somewhat difficult to distinguish from one another owing to the similarity in colour, the changes in growth due to age and locality and the slight variation in the number of rays of fins and scales. The young ones, as a rule, are of a more or less orange or scarlet colour and possess bright longitudinal bands in the immature stage. Those residing in backwaters, have a purplish tinge.

The colour of the adults vary from olive green to dark brown above, white or deep orange below with brownish irregular streaks and spots on the sides. The body colour, as stated above, also changes according to the colour scheme of the surroundings when excited.

Day (1865) described 9 different species but he was doubtful of two species being genuine. Jerdon (1848), Hamilton Buchanan, Bloch, Bleeker, Sykes, Mc Clelland, Shaw, Gunther, Lacepede, Peters (1868) and Cuvier and Valenciannes, have all studied these fishes and described them.

The table appended, gives the distinguishing features of classification of the different species of murrel recorded by Day.

However, the following are the important species available fairly commonly in South India:—

| *Scientific name.* | *Tamil name.* | *Telugu name.* | *Malayalam name.* | *Punjab name.* |
|---|---|---|---|---|
| *Ophiocephalus striatus*, (Day) | Verahl | Korāmeenu | Vral | Kubrah. |
| *Ophiocephalus marulius*, (Blochi) | Avuri ; Poo-Verahl | Poochepa Poomatta | Vrahl | Sawol Dowlah. |
| *Ophiocephalus punctatus*, (Blochi) | Koravai | Matta ; Matta gidasa | Koravai | Duchinge. |
| *Ophiocephalus gachua*, (Ham) | Para Koravai | Thullurayis | Koravai | Doariah. |

## FEEDING HABITS.

Murrel is an omnivorous and predatory fish. It feeds on worms, insects, small fishes, tadpoles and frogs. Eating the young ones of its own race is not uncommon. They assist in keeping water pure by destroying either animal or vegetable substances that might come in their way.

The fry of murrel especially those of *O. striatus* and *O. marulius*, are predominantly insectivorous in their feeding habits. They feed mainly on dipteran larvae. Copepods like diaptomus and cyclops also are ingested. Cannibalistic tendencies are sometimes noticed. The young ones of *O. punctatus* feed on protozoans (*Paramoecium, vorticella, stylonichia*), daphnids, copepods, dipteran larvae, ephemeropteran larvae, chironomid larvae and filamentous algae.

*O. marulius* is highly carnivorous in the adolescent and adult stages. They feed on live fish (minnows) and frogs. Only in about 10 per cent of the cases examined, had the fish ingested dead fish and kitchen refuse of animal nature. They are also very cannibalistic so much so in domestic wells and other small pieces of water, no more than a single individual survives. In one instance, a large specimen was noticed to have snapped up fowls and crows which happened to fall into the well.

*O. striatus* is also predaceous but to a lesser degree than *O. marulius*. It feeds on small fishes, frogs, worms and insects.

*O. punctatus* has a very negligible piscivorous tendencies. They feed chiefly on aquatic insect stages such as larvae of ephemerids, chironomids, dragon flies, water beetles like cybister and aquatic bugs like Notonecta and Belostoma. Crustaceans like copepods (diaptomus and cyclops) cladocerans and shrimps are also found eaten by this fish. Caterpillars, small crabs, molluscs (*pila* and *Ariophanta*) and weeds like *spirogyra* and *hydrilla* were observed in the gut contents. Fish contributed to only a very low percentage in the natural diet though under aquarium conditions, *O. punctatus* is noticed to swallow small live minnows.

## BREEDING HABITS.

Murrels are monogamous, i.e., the sexes are separate. Noticeable sexual dimorphism in the female being much larger than male, is described [Alikunhi (1947)]. It is the reverse in the case of *O. suratensis*. They attain maturity at the size of 30 to 35 cms. (12 to 14 inches) in *O.marulius*, 25 to 30 cms. in *O.striatus* and 12 to 15 cms. in *O.punctatus*. They build nests for laying their eggs. The nest is but a shallow depression cleared in the weedy margins by pieces of weeds bitten off by the breeding ones. Some breed in wells or stone-margined receptacles for water like dilapitated fort moat waters as in Arni, Gingee or others in holes and crevices of boulders among weedy margins of the river banks. While the nests of *O. striatus* are wide and formed in deeper waters, those of *O. punctatus* are formed among the bushes in the shallow crevices at a depth of ($1\frac{1}{2}'$) 44 cms. in ponds, those of *O. marulius* in not more than (4′) 122 cms. depth and (2′) 61 cms. away from weedy margins under shade, from interweaving stems and blades of *vallisneria*-*O. striatus* is said to construct its nest with its tail among the vegetation near the edges of the tanks. While it bites of the ends of the weeds which grow in the water, the ova are deposited.

Strong parental care of the eggs and young ones in murrel, is an important feature. The male keeps guard and if it is captured or killed, the partner takes the job. The parents, however, jealously guard the eggs and do not seem to take any food during the period of guarding. They look after the young ones till they are able to fend. As the shoals of fry move, the parents hover over the shoal like a parachute. When the young ones grow to independent size, they are driven out or sluggish ones are devoured by the parents who, no longer, cherish the idea of guarding them. It is desirable, at that time, to extricate the young ones which are about 7·5 to 10·0 cms. (2—4 inches) in size from the adults. *O. punctatus* however, abandon their young ones when they are (2 inches) 5·0 cms. long.

Murrels become mature in the first year itself and begin to breed prolifically thereafter. Murrel breed twice a year. It is, however, doubtful whether the same pair participate in the function. The breeding season coincides with the monsoonic months in the case of *O. striatus*, *O.punctatus* and *O.gachua* but not so in the case of *O. marulius*. The breeding seasons are from January to February and June to July in *O.striatus* January to February and July to August in *O.punctatus*, March to June and October to December in *O. marulius*, and December to January and June to July in *O. gachua*. The eggs are large, transparent, golden-yellow or ambre coloured and pelagic. The egg contains a single large oil globule above the golden-yellow yolk. The eggs are 1·25 m.m. in diameter. Oviposition takes place in the night. The eggs laid vary in number from a few hundreds to a few thousands up to

4,000, depending upon the age and size of the fish. Alikunhi (1946) recorded broods of 1,222 fry of 3 to 4 m.m. and 448 fry of 6 to 8 m.m. of *O.punctatus* in Chetpet swamps in the month of December and several pairs guarding the broods. The oval mass are spread like a sheet on the surface in the sub-circular area in the centre of the nest.

The average time of hatching of eggs is 24 hours depending upon the strength of the sun. Within about 8 hours the outline of the embryo becomes evident from the yolk mass, the eyes and auditory sacs are developed within 16 hours. The heart begins to beat and the yolk sac circulation starts soon after this. While hatching, the embryo rotates within the egg sac. On hatching, the larvae measure 3·25 m.m.

The various stages of development of the egg are given below :

| *Day.* | *Length in m.m.* | *Principal changes.* |
|---|---|---|
| (1) | (2) | (3) |
| 1 | 3·5 | Yolk sac circulation established black pigment cells develop in the eye region. |
| 2–3 | 4·5–5·0 | Pectoral fins develop-mouth opens respiratry movements begin. |
| 5 | 6·5 | Larvae leave the surface and swim freely at all levels-light yellow spots appear over eggs. |
| 7 | 7·0 | Caudal appendages appear. |
| 12–15 | 8·0 | Posterior end of notochord bent up. |
| 28 | 9·10 | Caudal rays branched and articulated with the basal cartilage—Larvae rise to the surface and begins to gulp air. |
| 37 | 10 | Dorsal and anal rays appear. |
| 40 | 10·25–13 | Rudiment of dorsal and anal fins appear and separated from caudal. |
| 63 | 17 | End of larval development-body organs become established. |
| 73 | 25 | Fry in an active state and plays about hiding in mud. |

The process of larval development is more or less the same among the different species except for some accelerated rate of growth in the pre-larval stages in *O. punctatus*. The larvae or fry wander together in rows as if they are moving in a procession, to the bottom sand, on the third day.

## CHARACTERISTIC COLOURS OF FRY

*O. striatus*.—The body is of brown and pink on fourth day. On either side of the body there is a broad reddish orange band (almost to the height of myotomes or body segments) extending from the eye on each side with rounded edges at the base of the caudal fin. There is a light golden occipital point and the base of the anal and dorsal fins, is black along the whole length. This livery persists till the fry reaches a length of about 40 m.m. (three months old fry). Then the colour changes.

*O.punctatus*.—The body is of black and yellow colour when 4 days old. The colour changes to dark olive along the back and sides becoming slightly pale laterally with close set strips along the sea. Then three longitudinal, golden yellow bands appear on the sides extending from the snout to one-third of caudal fin. Anteriorly one of them thins out and meets its fellow on the tip of the snout, then continues and extends along the base of dorsal fin to the root of the caudal fin as a median dorsal band. This median band is narrow but more distinct in younger stages and has two spindle shaped patches in front of dorsal fin.

As it grows to about 5 cms. (2 inches) in size, the median band disappears, the dark dorsal colour changes into dirty brown patches coalescing with the golden bands, which however persist on the head for a longer time.

*O. gachua*.—*early fry*.—There are two horizontal bands of dark brown colour one dorsal and one ventral with a pigmented area between them along the mid-lateral line. Of the two, the ventral band is more conspicuous being very broad on the abdomen and tapering gradually into a sheath posteriorly. A number of pigmented spots are found on the head, a cone of which occurs behind each eye. Scattered spots are found on the continuous median fin.

*Later fry*.—Body is of pale olive brown and sides are crossed with 10 or 12 bands with their apices on lateral line pointing forwards.

*O.marulius*.—The fry are golden yellow in colour. When the fry are (an inch) 2·5 cms. in size black pigments appear on the dorsal and the ventral sides, leaving a yellow band on the lateral line. There is often a large ocellus with a light edge on the last rays of dorsal fin. Caudal fin barred or spotted with white or orange.

## METHOD OF CAPTURE

Murrels are usually caught by hook and line with live bait such as frogs or minnows. A simple type of trap called the 'murrel noose' (Kannikodi in Tamil), is also used. This is a small bag like structure, two feet long, made of palmyrah fibres or weeds and open at one end the diameter being just about the thickness of a murrel of good size. These are set in shallow waters along the margin among weeds. As the murrel has a habit of swimming into shallow waters and hunting for its prey at night, it unwarily enters those traps and gets caught. Once it enters, it cannot go back as the gills and the pectoral fins will retard the way. The entrapped fish is removed in the next morning.

Is some places like 'Veeranam' tank in South Arcot district, murrels are enticed by lights in the night and when they approach, they are speared with a crude steel weapon or spear.

Usually the capture of murrels becomes prominent during hot weather when shallow, rain-fed and river-fed tanks and ponds, go dry in South India. In every village the fish population including the murrel collection in the bottom of the tanks, falls an easy prey to the cast nets and hand nets of the villagers.

## CULTURAL IMPORTANCE

Murrel forms a major bulk of the indigenous fishery of the tanks and ponds of Madras State. Of the four common available species, three species, *O. striatus*, *O. marulius* and *O.punctatus*, contribute to the normal murrel fishery. Two of these three species are carnivorous and even cannibalistic. It is well suited for pisciculture on account of its hardy nature and the ease with which it can be transported and planted. Though it is predaceous, it can be reared in isolated waters. It is easy to collect the eggs of the murrel and hatch them. But it is difficult to rear them into larvae. After a certain stage, they require a special type of live food in the shape of worms, aquatic insects, tadpoles, etc., whereas the adult fishes thrive well on any live food. To secure fry for stocking, a few select breeders can be released in ponds with shallow margins and with plenty of weeds suitable for nesting and fed on a diet of small carps, tadpoles and frogs. After the breeding season, when the fry are abundant, these must be transplanted to marshes teeming with the special type of live food mentioned above and reared to a marketable size.

The earliest attempts in murrel culture in Madras State was by Mr. H. C. Wilson, pisciculture expert of the department in Sunkesula fish farm situated on the banks of the river Tungabadhra near Kurnool. The murrel fry or brood were caught by the use of a special device called the ‘ Murrel Brood Trap ’. It is a square wooden frame of about 91 cms. (two feet) long each and 20 cms. (two feet) high with a fine wire mesh bottom. The frames are pierced with a number of holes. Each frame is made with a sleeve in the top edge so that a number frames can be inserted one over the other. When a brood of murrel is noticed, they are trapped by sinking one or more frames piled up till the edges of the topmost frame stand above the level of water. The eggs most frequently turn opaque due to the attack of water flea and daphnids. When the fry grow to a fairly big size, they are transferred to nursery ponds. Transport of murrel fry is usually made when the usual orange red colour of fry is about to disappear.

Adult murrels never keep in good condition on a diet of artificial food. To maintain a few of them in a pond, an abundance of weeds and a diet of live minnows, carps, tadpoles and frogs are quite essential. In view of the above difficulty, planting them in natural, shallow swamp with abundant vegetation and insect larvae was found to be the best method of culturing the fish. So Mr. H. C. Wilson the pioneer of Inland Fish Culture in our State, selected a vast swamp, Edrur swamp about six miles from Sunkesula and stocked it with the young ones. The adults were fished out annually and stocked in market ponds for regular supply to the Kurnool market. The difficulty of rearing fry was thus counter-acted by the ease of transport. As the fish has accessory respiratory organs to breathe atmospheric air, it would live out of water for a fairly long time.

Taking advantages of this habit special “ Murrel carrier ” was designed to transport murrels over long distances without water. It is a special kind of tin carrier with a perforated lid and locking arrangement. The carrier itself can hold trays of about 15 cms. (6 inches) height each. One or two murrels are placed in each tray with moist weed to keep the gills wet and to prevent the fish from fighting with its compatriot. The carrier, after filling, is locked up and transported. No water is put in except for sprinkling the weeds with water to keep them wet. In this position they stand transport very well over long distances and can be marketed fresh on reaching its destination.

In Punjab, murrel culture was tried in Madhopur. Five pairs of murrels kept in a tank bred. The fry were grouped and kept separately and fed with different kinds of food, viz. (*a*) goat’s liver, (*b*) silk-worm cocoon and (*c*) a mixture of wheat flour, silk-worm cocoon and goat’s liver. It was found that those fry fed on (*a*) grew fastest while those in other categories were the bleakest. Further 76 robust fry were stocked in a tank. After a time, only 46 adult fishes of about 35 to 70 cms. (14 to 28 inches) and six fry of about 15 to 18 cms., were caught.

In Bombay, 278 fingerlings of murrels of about 5·0 to 8·0 cms. (2–3 inches) were stocked in a pond in June 1938. Only 42 murrels could be recovered when fished in April 1939. The growth recorded among the recovered ones, however, was phenomenal attaining a maximum of 48 cms. (19 inches) in about 10 months. This encouraged hopes of extensive murrel culture in tanks and ponds. Similar venture of stocking during the next year proved useless. The only difference between the two experiments was that some Megalops were stocked in addition in the first case and not in the second case. It was therefore evident that Megalops served a greater cause as food for the rapid growth of murrel than anything else.

The experiments in Punjab and Bombay make it clear that, under ordinary circumstances, the murrel is not a suitable fish for culture in ponds and lakes. But marshy and swampy areas like Edrur swamp in Kurnool, weedy patches of swamp in Poongar below the Bhavanisagar Dam, in the township below the Bhavanisagar fish farm, etc., which are unsuitable for quick growing carps, can be used profitably for murrel culture provided sufficient live food in the form of tadpoles and frogs, minnows, insects, etc., are made available.

The murrel is comparable to the carnivorous, large mouth Bass of U.S.A. (*Micropterus salmoides*) which is extensively farmed in weedy marshes. Americans have an admirable prolific forage fish, the Blue gill sun fish (*Lepomis macrochirus*) which breeds in large numbers and provide abundant food to the carnivorous Bass. *Tilapia mossambica* Peters imported into India in the recent years, stand a fair comparison as a forage fish to the Blue-gill sun fish. In fact, *Tilapia* is growing so prolifically that the department had to think about exterminating them in certain ponds and tanks. For example, Mariamman Theppakulam in Madurai, was one such tank. The stocking of *Tilapia* yielded some very good results in the first few years of its stocking. In later years, the breeding of this fish became abundantly prolific and the average off-take size of the fish was very small resulting in its poor demand among the consuming public. So measures for mitigating the breeding potentialities and increasing the growth rate of *Tilapia*, had to be thought of. Introducing murrel in association with *Tilapia*, was thought of and murrel fingerlings were introduced into the pond. The results were expected to be bright and encouraging. But it was not so. Yet the matter continues to be adverse as regards *Tilapia*. Though occasional murrel catches were found to give encouraging results, the desired effect was not achieved. Probably *Tilapia*, which is also monogamous like murrel and has similar breeding habits of laying fairly large number of eggs in pits and getting them fertilised has gone ahead of murrel in its properties of parental care and has the advantage of keeping the fertilised eggs in its mouths unlike the murrel in the nest or crevices, free from all the ravages of the open life in the medium. Its decompressed and broad bodily shape with median fins, have an adverse effect on the voracious avidity of murrel. Thus the experiment did not prove successful. As in Bombay, some other varieties of less harmful fish is to be tried as forage fish for the success of murrel culture. Small minor carps like *Cirrihina reba Barbus spp.* minnows, top minnow, etc., may have to be tried as forage fish for the murrel.

Another instance of ineffectiveness of murrel is recorded by De Zylva. (Ceylon) (1958) Gowrami (*Osphronemus goramy*) which was stocked in some garden ponds in Peradeniya hills in Ceylon, got washed off by sudden floods and the stock seem to have been carried over by floods to the plains through the Mahaweli River. The river gets divided into three branches in the plains before joining the sea. In a village named Allai on one of the branches, murrel population seem to have been predominant when De Zylva visited the place for the first time about 10 years ago. During his second visit, he found that, in the catches, Gowrami predominated forming 90 per cent while murrel formed only 10 per cent. This shows that there was no inhibitive influence of murrel on the growth of Gowrami though murrels were present in the area. Here too the causes may be simple as in the case of *Tilapia*. Gowrami is a fish having decompressed body and having a very pronounced type of parental care. Gowrami lays its eggs in an advanced type of nest built of weeds like bird's nest and the eggs which are fairly large and whitish like pepper corn, are laid in it and guarded by the parents vigilantly. In such circumstances, the approach of murrel to the brood of Gowrami, will be a formidable task. Choosing the proper species of fish with which to stock the farm ponds is one of the most difficult and important decisions facing the pond owner and biologist in America. Great variation in fishing success in lakes containing marshy species has led to trials of a single species or a very simple combination of species.

The success of a species depends largely on its ability to survive and reproduce in the environment and its ability to compete with other species for food and space. Balance of the fish population is important since too few or too many replacements will offset the annual harvest and will usually result in over-population of one or other species if a combination is used. The best single combination in general use today in America, nay in the world, is the Blue gill-Bass combination. It has given the highest return. But fish Bass and Blue gills became good game fish for the owners to devote attention upon.

Various experiments were done to use different combination. Bass with a variety of Sun fish, called Redear Sun fish (*Lepomis microlophus*) was tested. It proved futile because this fish could not produce enough young ones to keep the population in balance. Further the fish is susceptible to sudden changes in temperature. Another fish, Round Flier (*Centrarchus macropterus*) was used in combination with Bass. This fish reproduced earlier than Bass and thus did not produce the desired effect. Certain other fishes tried, did not spawn in the ponds and exhibited low growth and this proved futile. Gizzard Shad (*Dorsoma cepedianum*) was tried with Blue-gill Bass combination. The shad competed very adversely for food with Blue-gill. Since Gizzard Shad would not take in bait or lure, the adults could not be thinned out or controlled by angling. They grew so rapidly that in one or two years, they became too large for the Bass to eat and so over-populated the pond and ultimately curtailed their own survival rate. So Bass yield also went low. Gold fish (*Carassius auratus*) which feed on insects, plankton and plant material was used as a forage fish. For some time it produced large numbers of young ones on which the large mouth Bass fed and grew. However, gold fish grew rapidly and unto a large size this Bass could not eat them. The pond became over populated with gold fish. Blue-gills, however retained the production of gold fish by eating their eggs. Golden shiner (*Notemigonous crysoleucas*) was tried in combination with the Blue-gill. But these competed directly for food and large shiners have been known to eat small fish. Slow growth and limited spawning period eventually led to the complete elimination of this fish by Bass. Top minnow (*Gambusia affinis*) was tried in combination with the Blue-gill Bass combination. These were also entirely eliminated in a few months by the Bass.

In such combination experiments, it is therefore essential to provide some control over the adult forage fish when they become too large for the piscivorous fish to eat. Many forage fish cannot be used because there is no way to control the adults and over-population results. The Blue-gill, however, suited admirably as it breeds throughout summer (May to October) providing a continuous crop of small fish as food for the Bass.

In over ten years of experimentation, the Blue-gill Bass combination has yielded an annual catch of 175 to 200 lb. of fish per acre. The Bass made up of 20 to 61 lb. of this yield in different ponds. Blue-gills and Bass maintained their numbers even under intensive fishing pressure. Paid fishermen could deplete the pond population by 50 per cent only and the catch per unit effort fell low.

The stocking rate for such combination was 100 Bass and 1,000, juveniles or 1,500 fingerlings of average 2 inches length of Blue-gill Sun fish per acre. Bass begin to spawn after they have spent two or three full seasons. So they must be fed well to grow. Since the Blue-gill spawn in their first year at least 50 per cent of the first planting should be of adult size to enable the fish to breed and over-populate the source to begin with. The subsequent crop was maintained naturally by the progeny of adults planted first. The Bass begin to feed on the progeny and keep control over the Blue-gills.

In America, there are over a million small farm ponds. Fish cultivation in these farm ponds is on increase. Some produce as much as 200 lb. of fish (91 kgs. per acre) by the popular Blue-gill Bass combination culture. Blue-gill sun fish (*Lepomis macrochirus*) is one of the widely distributed sun fish belonging to the Perch family. Its weight averages ¼ lb. and sometimes weigh 1 lb. Its colour varies usually with faint bars and dark lobes extending back from the gill covers. In short, it resembles *Tilapia*. It is found in Central States in America as far as Colorado. They thrive in farm ponds and lakes. Blue-gill are reported to attain 2 cms. (0·7 in.) 2¼ months [Surber (1948)] and 8 cms. (three inches) in 8 months [Bennett (1948)]. One year old Blue-gills average about 24 cms. (9·5 inches) in length, two years old about 14 cms. (5·5 inches), three years old about 6·6 inches and four years old about 20 cms. (8·0 inches). Under very favourable conditions the growth average 15 cms. (six inches) in 17 months [Krumholz (1949)]. The increase in weight averages 300 per cent in 10 months in Blue-gills [Rounsefell and Everlast (1958)] Blue-gills mature in about twelve months. In America Basses are the finest of fresh water game fish which includes thirty and odd species. These live in warmer lakes and ponds of America and are widely distributed in the native waters. These fishes build nests and the male guards eggs and fry as in murrel. This also belong to perch family. Bass fry are 28 cms. (eleven inches) after thirty days of hatching and attain a growth of 14 cms. (5·6 inches) in 5 months. It becomes mature at the end of two to three years of age. Similarity of the problems of Bass culture in combination with the Blue-gill Sun fishes, arises in the case of murrel culture in our waters which requires deep study with different varieties of the economical forage fishes available in our waters.

As already mentioned, murrel forms an important indigenous fishery in our inland waters. The murrels form the third most important variety of Inland fishes next to carps and cat-fishes in the Madras State, as evidenced by a statistical study made of weight and value of fish supplies of about 50 inland centres in the various districts (Andhra, West Coast and Tamil Nad regions) of the composite Madras State for the quinquennium (1948 to 1952) (Chacko and George) *vide* annexure for the figures of murrel supplied alone tabulated for Andhra West Coast and Tamil Nad regions). It will be noted that there was a significant increase in the total availability of murrels year by year in the Tamil Nad regions during the five years showing an increase of more than 200 per cent at the end of the five years. This shows that murrels form an important fishery in the present Madras State. As separate figures for later years are not available, the progress in the murrel fishery could not be further discussed. Fishing season for carps, cat-fishes and murrels in inland waters generally occurs from January to June which coincides with the period when most of the inland waters go dry.

The importance of the murrel fishery in other areas is also discussed here. In the detailed account of fish supplied to Rajahmundry town in Andhra region, it was noted that murrel formed nearly 4·5 per cent of the total annual fish supply, the supply being uniform throughout the twelve months unlike other fishes. The average rate fetched was Re. 0·31 to 0·34 per kg.

The detailed study of fishery in the Kanigiri-Duvvuru Reservoir in Nellore district was conducted in 1951 by the Department. This reservoir is one of the largest irrigation tank in composite Madras State extending to about twenty square miles with a FTL of 22 feet and an embankment of over fifty furlongs. It holds a permanent supply of water from Pennar river through the Sangam Anicut and irrigates about 90,000 acres of land. The total landings of the reservoir were about 248 tons per annum with an average lease amount of Rs. 17,000 per annum. Though the reservoir was being stocked with one of the major carps, (*Labeo fimbriatus*), by the department for fish production, the major portion of the fishery was contributed by the murrels, *O. striatus* and *O. punctatus*. The productivity of the reservoir worked out to 38 kgs. per acre (84 lb.) whereas the maximum and average production of fish per acre from lakes of similar area according to Rounsefell's estimate (1946) are 26·4 kgs. (58·1 lb.) and 13·5 kgs. (29 lb.) respectively. Even in such a highly productive lake, the murrels predominated. The fishing tackles used and their average catches per fishing day are given below :—

| *Fishing tackle.* | *Average catch per net per fishing day.*<br>LB. |
|---|---|
| 1 Wall net | 25 |
| 2 Stake net | 12 |
| 3 Cast net | 16 |
| 4 Dip net | 2 |
| 5 Basket trap | 2 |
| 6 Plunge basket | ½ |
| 7 Hook and line | 1 |

A survey of the fisheries of the Kadamba tank in Tirunelveli district, a river-fed irrigation tank of about 1,650 acres with a surplus weir of 460 feet long and a FTL of 18 feet irrigating about 2,776 acres revealed a natural fishery of murrels *O. striatus*, *O. punctatus* and *O. gachua* besides other fauna. It was fetching a nominal rental of Rs. 80 to 100 only per annum. After departmental take over and development by introduction of some major carps and Chanos, the fishery of the tank was considerably developed. In 1950–51 the total departmental catch was 20,250 lb. and those of the licencees were 160,775 lb. the estimated total catches being about 1·8 lakhs of lb. Of these, murrels formed 4,098 lb. i.e. about 20 per cent of the total catches of the department. Analytical data of licencees catches were not given to assess the potentiality of total murrel population in the tank for that year. However, the high percentage of murrels in the departmental catches may be taken as an index of overall population of the tank. The occurrence of *O. gachua* in the tank denotes the migratory habit of this fish from the river feeding the reservoir. This reservoir, as of late, became naturally populated with another salt water fish, *Etroplus surantensis*, due to migration from the Thambraparni estuary through the Srivaikuntam channel.

Poondi reservoir formed in 1944 is another river fed reservoir. It is 12·5 square miles in extent with a FTL of 137 feet mainly intended to augment the supply of drinking water to Madras City. In 1948 this reservoir accounted for a total landings of 136 tonnes valued at Rs. 38·600. In the qualitative and quantitative analyses, the murrels came third in order of abundance, *Cirrhina reba* and *Notopterus* occupying the first two ranks. Murrels formed nearly 5·4 per cent of the total catches.

Murrels are also recorded as forming natural fishery in higher elevations as well as in Kodaikanal lake [Chacko (1950)], in Ippur fish farm in Nellore district (Wilson) in Malampuzha reservoir in South Malabar [Achuthan Nair (1954)] in Chetpet fish farm in Madras and in other inland waters during 1946–47 [Chacko (1948)]. In the Chetpet farm the murrels breed prolifically during the rainy months. Observation on the breeding habits rate of growth, age maturity and food of fry and fingerlings were made in Chetpet farm under the Madras Rural Piscicultural Scheme (Alikunhi, Chacko and others). The developing eggs of murrels were collected and reared to hatchling sizer in the laboratory. The results compared well with the rates of growth recorded by Willtey (1909) and Raj (1916). In a natural pond, a brood of fry of an average length of 30 mm. was found to have grown by 12 mm. in 18 days. In a second pond, fry of 47 mm. of average length, had grown to 55 mms. in 21 days. In a third pond, the fry of average length of 47 mm. have grown to 70 mms. in 26 days and to 109 mms. in 60 days. Thus the average rate of growth of 1 mm. takes from 1 to 3 days in murrels. Tagging experiments were also conducted. The studies revealed a fair growth of 44 mm. per month. Three hundred fingerlings were transferred to a small tank which contained plenty of forage fish. The size weight relationship of these fingerlings was studied. It was found that the fingerlings have reached an average size of 19·8 m.ms. 9 ins. and an average weight of about 80 gms in 4½ months. While the total length increased by about three times the length at stocking, the weight increased by about sixteen times. (Alikunhi, 1946–47).

In the rivers, *O. marulius* is reported to grow to a size of 122 cms. (4 feet). A big murrel of about 120 cms. weighing about 4 kgs. (9 lb.) was caught in Poondi below the anicut in 1949 by me. In irrigation wells, with plenty of fauna like small minnows and frogs, they grow to a size of 40 cms in one year (MD. Menon). According to Chacko (1953), these attain a length of 76 cms. (13 ins.) and a weight of about 2 kgs. (4 lb.) at the end of the first year. Since *O. marulius*, the river murrel, is predaceous and cannibalistic, it prefers live fish and frogs for its forage. It is therefore suitable for uncleared swamp farming and for culture in large irrigation wells. In farm ponds and tanks it could be only cultured in combination with a suitable forage fish or fishes like *Tilapia*, top-minnows and small minor carps.

*O. striatus*, the murrel, is reported to grow in tanks to a maximum size of 91 cms. (3 feet). In tanks containing a very large population of insects worms and frogs they grow to a size of 36 cms. in one year. The attainment of a growth rate of 30 cms. and a weight of 3 kg. (1½ lb.) in the first year by this fish were recorded (Chacko 1953). This is useful for culture in ' Punjai ' irrigation tanks, deep domestic wells and weedy ponds. Its predaceous nature will however, require it to be reared alone or in combination with fast breeding fishes like minnows, top-minnows, *Barbus*, *Rasbora*, etc., which breed prolifically and hence no artificial food is necessary. Otherwise it is to be fed with artificial food like kitchen refuse, offal, etc.

*O. Punctatus* grow to a maximum size of 26 cms. In ponds containing large quantity of insects and minnows, it grows to a size of 21 cms. in the first year. It is very useful for culture in fortified swamps and shallow muddy waters like those of paddy fields, small pools, tanks, ditches and wells. Because of its very low piscivorous habits the fish can be tolerated in regular fish ponds also. The diet being arthropodan and varied, the feeding problem can be easily solved in its culture.

## RECOMMENDATIONS

The fry and fingerlings *O. marulius* can be collected from the deeper river sections having sandy bottom and submerged rocks from May to August and November to February from the Bhavani river and the Cauvery river systems. The fry and fingerlings of *O. striatus* and *O. punctatus* can be collected in large numbers from the paddy fields and uncleared tanks and swamps of the State during the monsoonic months. The fry are very delicate until the larval colouration is changed. Only when the post larval colouration develops the young ones stand transport well. The adolescent and adult murrel can be transported for less than 48 hours packed in wet moss in special container because of their air breathing habit. Since the collection and transport of fry and fingerlings for stocking do not offer much difficulties, this fish is admirably suited for long distance transport.

As murrels grow faster on live food and attain considerable size for marketing in a relatively short period, and as many varieties of uneconomical and small sized fishes like minnows, top-minnows, Barbus and other minor carps are available in Madras, experiments on culture of murrel in combination with other fishes may be tried as in America. As there are a number of village ponds full of vegetal and other faunal populations in the various blocks, development of fisheries on this line is worthy of consideration. Since an average yield of 175 to 200 lb. per acre is easily achieved in colder countries like America the biological productivity in the tropical areas in our Madras State may be capable of a two-fold increase with the assistance of fertilisers. Organic fertilisers are in-advisable. According to Swingle and Smith (1950) inorganic fertilisers are more valuable. Organic fertilisers are unpredictable of results, and ruin the aesthetic value of a pond and are liable to transmit parasites and diseases. Further larger amounts of organic fertiliser are required in comparison with the inorganic e.g., one ton of manure equals roughly 100 lb. of 10–5–10 NPK. Inorganic fertilisers, can be prepared with accurate amount of desired elements. They are cleaner and they can be more easily applied to provide a more desirable pond.

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*Table of distinguishing features for classification of Ophiocephalus spp.*

| *Distinguishing features.* | *Marulius.* | *Leuco-punctatus.* | *Pseudo marulius.* | *Barca.* | *Micropeltes.* | *Striatus.* | *Stewartii.* | *Gachua.* | *Punctatus.* |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1 Fin Formula .. .. .. .. | D—45–55 | 47–53 | 52 | 47–52 | 43–46 | 37–45 | 39–40 | 32–37 | 29–32 |
| | A–28–36 | 28–35 | 35 | 34–36 | 27–30 | 23–26 | 27 | 21–23 | 21–23 |
| | L1–60–70 | 59–60 | 64 | 60–65 | 95–110 | 50–57 | 47–50 | 40–45 | 37–40 |
| | L. tn. 4½–5½ | 4½–5 | 6/14 | 5/13 | 7/13 | 4½–5½ | 4½/9 | 3/7 | 4–6 |
| | 13–13 | 13–13 | | | | 9–10 | | | 9 |
| | P–18 | 18 | 17 | 16 | 15 | 17 | 17 | 15 | 17 |
| | V–6 | 6 | 6 | 1/5 | 1/5 | 6 | 6 | 6 | 6 |
| | C–14 | 14 | 15 | 19 | 15 | 13 | 14 | 12 | 12 |
| 2 Caudalfin to the total length .. .. | 6–7½ | 6 | .. | 4½–5½ | 6½–7½ | 6 | 5½ | 5½–6 | 5¼–6¼ |
| 3 Height of body to the total length .. | 7–7½ | 7¼ | 4 2/3 | 5½–7½ | 6–6½ | 6–8 | 7/8 | 6 | 5½–7 |
| 4 Length of head to the total length .. | 4–5 | 4 | 3¼ | 4–4½ | 3½–3⅔ | 3⅓–4 | 4 | 3½–4¼ | 3⅓–3⅔ |
| Rows of scales between mouth and base of dorsal fin. | 16 | 16 | 16 | 15 | 22 | 18–20 | 13 | 12 | 12 |
| 6 Rows of scales between eye and angle of pre opercle. | 10 | 10 | 10 | 9 | 16–17 | 9 | 5 | 4–5 | 5 |
| Colour of fish— | | | | | | | | | |
| (i) Young .. .. .. .. | Orange banded, having white spots and a black light-edged ocellus at root of caudal fin. | Orange banded, having white spots, no caudal ocellus. | Orange banded, a black spot at the base of caudal. Greyalors and lighter on the sides and below. A black ocelles at the base of caudal. | Dark violet colour, spotted on body and fins. | Young scarlet with 2 black bands; grey with black spots. | Dark grey passing in stripes into the white of the abdomen. | Purplish, spoted with black. | Pectoral banded * vertical fins edged with red. Greenish above. | |
| (ii) Old .. .. .. .. .. | Greyish green. | Greyish green. Abdomen Orange Numerous white spot on the body. | | | Greyish brown with small brown on the sides. | | | | |
| 8 Length of fish .. .. .. | (4 feet) | 3 feet or more. | 3 feet. | 3 feet. | Atleast 3 feet . | 3 feet or more. | 10 inches. | 13 inches. | 12 inches. |
| 9 Distribution .. .. .. .. | Through out India to China. | Deccan and sea coasts of India to China. | India. | Large rivers of Bengal and Assam. | Western coast of India to Siam and Malaya. | India to China, swampy and grassy tanks, fresh-water 3 feet or more in depth. | Cachar and Assam. | India, Burma and Andamans, wells, etc. | India and Burma nearer the sea coast and back-waters, prefers stagnant waters to running water. |

* Spotted or banded vertical fins dark with a light edge,

## Landings of murrels in various districts of composite State of Madras, 1948-52.

| | 1948. | 1949. | 1950. | 1951. | 1952. | Total for five years. |
|---|---|---|---|---|---|---|
| | LB. | LB. | LB. | LB. | LB. | LB. |
| *Andhra Region.—* | | | | | | |
| Srikakulam | 27,520 | .. | .. | 15,400 | 2,560 | 45,480 |
| Vizagapatnam | .. | 29,918 | 39,730 | 45,971 | 69,771 | 185,390 |
| West Godavari | 231,221 | 256,481 | 131,495 | 524,618 | 89,696 | 1,233,511 |
| East Godavari | 165,571 | 85,970 | 96,437 | 53,547 | 137,595 | 539,120 |
| Krishna | 105,928 | 23,563 | 271,261 | 186,479 | 141,182 | 658,413 |
| Guntur | 235,325 | 164,532 | 317,176 | 16,638 | 16,670 | 750,341 |
| Nellore | 41,180 | 18,047 | 48,080 | 22,204 | 18,101 | 147,612 |
| Kurnool | 1,852 | 2,367 | 4,525 | 4,275 | .. | 13,019 |
| Bellary | .. | .. | 2,391 | 80 | 380 | 2,851 |
| Anantapur | 415 | 1,533 | 15 | .. | .. | 1,963 |
| Chittoor | 3,114 | 2,199 | 11,065 | 6,071 | 1,053 | 23,502 |
| Cuddapah | .. | .. | 81 | 42 | .. | 123 |
| Regional total | 812,126 | 584,610 | 922,256 | 875,325 | 497,008 | 3,671,325 |
| *West Coast Region.—* | | | | | | |
| Malabar | 7,568 | 14,442 | 10,522 | 13,188 | 7,925 | 53,645 |
| South Kanara | 14,920 | 967 | 16,724 | 19,189 | 9,302 | 611,102 |
| Regional total | 22,488 | 15,409 | 27,246 | 32,377 | 17,227 | 664,747 |
| *Tamil Nad Region.—* | | | | | | |
| Chingleput | 1,983 | 14,145 | 4,100 | 2,335 | 16,952 | 39,515 |
| North Arcot | 1,360 | 3,006 | 2,297 | 2,596 | .. | 9,268 |
| South Arcot | 20,075 | 11,875 | 3,854 | .. | .. | 55,804 |
| Salem | 2,616 | 225 | .. | .. | .. | 2,841 |
| Coimbatore | 6,467 | 855 | 2,088 | 344 | .. | 9,754 |
| Thanjavur | 12,950 | 65,559 | 41,589 | 167,480 | 4,867 | 292,445 |
| Tiruchirappalli | 32,246 | .. | 84,504 | 6,526 | 187,250 | 310,526 |
| Madurai | 14,708 | 20,427 | 5,619 | 2,903 | 5,178 | 78,835 |
| Tirunelveli | 3,820 | 3,406 | 4,286 | 4,420 | 3,958 | 19,890 |
| Ramanathapuram | .. | .. | 5,933 | 4,677 | 1,364 | 11,974 |
| Regional total | 96,234 | 119,498 | 154,270 | 191,281 | 219,569 | 830,852 |
| Total for the composite State— | | | | | | |
| Weight in lb. | 930,848 | 719,517 | 1,103,772 | 1,098,983 | 713,804 | 5,166,924 |
| Value in Rs. | 317,768 | 219,269 | 342,031 | 350,322 | 309,749 | 931,339 |

# FOULING ORGANISMS OF THE EDIBLE OYSTER CULTCH IN THE ENNUR BACKWATERS

BY

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## INTRODUCTION

Studies on organisms which settle on objects kept exposed in sea water have been made by several Indian research workers such as Paul (1942), Kuriyan (1950), Kuriyan and Mahadevan (1953) and Daniel (1954–55). Similar settlement was observed in brackishwater also while conducting experiments on edible oyster spat collection in the Kortalaiyar estuary for a period of two years, eight months from January 1957. This settlement was of special interest as it played an important role in the collection, culture and growth of edible oysters.

## OBSERVATIONS

Rectangular boxes each 4 feet long, 2½ feet broad and 6 feet high with adequate space for free inflow and outflow of water were implanted in 6 feet to 8 feet of water over the oyster beds in the estuary. Each box was fitted with three crates. Each crate carried four tiers of country roofing tiles, coated with a mixture of sand and lime and dried. The oyster larvæ settled on these along with a variety of other organisms which varied in their occurrence from time to time. Monthly examination of the cultch for oyster spat revealed the presence of these fouling organisms which consisted of sedentary forms, temporary occupants, and permanent inhabitants of the cultch.

Many of these were keen competitors with the oyster spat for food and space. Certain of these organisms were predators that preyed on the oyster larvæ while some were mud-dwelling forms that accumulated large quantities of silt thereby fouling the settling substratum of the oyster larvæ.

One set of the cultch was completely cleaned every month before replacement so that a clear picture of the organisms which have settled down during each month could be had. A second set was cleaned of all organisms except the oyster spat to enable a study of their growth. A third set was replaced as it was after examination to enable a study of the growth, increase, decrease and mortality of the fouling organisms as well.

The organisms collected from the cultch on these occasions have been identified and classified as follows :—

*Protozoa*—Vorticella sp.

*Coelenterata.*—Laomedia spinulosa Bate, Obelia sp. Zoanthus sp. Alicia sp.

*Platyhelminthes.*—Planarians.

*Polyzoa.*—Membranipora membranacea.

*Echinodermata.*—Salmacis virgulata, Ophiocnemis marmorata.

*Mollusca.*—Meretrix casta, Mytilus viridis, Modiolus undulatus, Modiolus metcalfei, Modiolus striatulus, Arca complanata, Venerupis macrophylla (Deshayes), Patella sp. Nassa jacksoniana, Avicula sp., Libitina sp., Cerithidium fluvialis, Cerethium erranosum, Ostrea madrasensis, Anomia sp., Vivipara sp., Nuculana mauritiana, Nudibranchs.

*Annelida.*—Hydroides norvegica gunnerus, Dasychone cingulatus, Sabellaria sp., Amphinome sp. Phillodoce sp., Marphysa sp., Eunice sp., Serpula vermicularis., Lycastis sp. Eurythoe sp.

*Cirripedia.*—Balanus amphitrite variegatus, Balanus amphitrite communis.

*Decapoda.*—Metapenaeus monoceros, Metapenaeus dobsoni, Penaeus indicus, Penaeus carinatus, Alpheus sp., Palaemon sp. Ozius rugosus, Grapsus strigosus, Pilumnus vespertilio, Gonisoma crucifera, Clibanarius olivaceus (Henderson).

*Amphipoda.*—Corophium madrasensis (Nair), Stenothoe gallensis, Elasmopus pectericrus (Bate).

*Isopoda.*—Cirolana pleonastica (Stebbe), Cirolana elongata (Mike Edwards), Idothea gracilleria (Dana).

*Arachnida.*—Pycnogonids.

*Pisces.*—Arius sp., Gobius sp., Boleopthalmus sp.

*Algae.*—Enteromorpha sp., Gracillaria sp., Lyngbya sp.

Sixty-three organisms including spat of *Ostrea madrasensis* and excluding diatoms and algal spores were recorded during the studies. The occurrence of these organisms varied from month to month. Forms which were absent in certain months, were rare in other months, common sometimes or even plentiful or swarming depending upon favourable or unfavourable meteorological and hydrographical conditions. Certain forms present in one year were totally absent in the other. Thus *Gracillaria sp. Lyngbya sp.*, *Anemones*, *Palaemon sp.*, *Salmacis virgulata* and *Arius sp.*, recorded on the cultch in 1957 were absent in 1958 while, Molluscan eggs, Ophiocnemis and Dasychone which were not observed in 1957 were collected in 1958. The following tables I and II give an idea of the seasons of occurrence of these organisms in 1957 and 1958 while Table III shows the changing metorological and hydrographical conditions experienced during the various months of the year April 1957 to March 1958.

TABLE I—*Showing the relative abundance of Organisms on the Oyster Cultch in 1957.*

| *Organisms.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 *Gracillaria sp.* | F | .. | .. | .. | .. | .. | .. | .. | .. | F | .. | C |
| 2 *Lyngbya sp.* | F | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | C |
| 3 *Entermorpha sp.* | .. | .. | F | F | .. | F | .. | .. | .. | .. | .. | C |
| 4 Encrusting sponges | .. | .. | F | F | F | F | .. | .. | .. | .. | .. | .. |
| 5 Anemones | .. | F | .. | .. | .. | .. | .. | F | .. | .. | .. | .. |
| 6 Hydroids | .. | .. | F | F | .. | F | .. | .. | .. | F | .. | C |
| 7 Polychaetes | F | R | F | C | C | C | C | C | C | F | .. | .. |
| 8 *Hydroides norvegica* | .. | .. | S | C | C | C | C | C | C | F | F | C |
| 9 *Modiolus undulatus* | F | R | S | C | C | C | C | C | C | F | .. | F |
| 10 *Meretrix casta* | F | .. | .. | F | .. | F | F | F | F | .. | .. | .. |
| 11 *Cerithidium fluvialis* | F | C | S | C | C | .. | .. | .. | F | .. | .. | .. |
| 12 *Lamellibranchs* | .. | .. | F | C | C | C | C | C | C | F | .. | .. |
| 13 *Nudibranchs* | .. | R | .. | F | F | F | .. | F | .. | .. | .. | .. |
| 14 *Anomia sp.* | .. | F | F | F | F | .. | .. | .. | .. | .. | .. | F |
| 15 *Mytilus viridis* | .. | .. | F | C | C | P | P | C | C | F | .. | .. |
| 16 Planarians | .. | .. | .. | .. | F | F | .. | .. | .. | .. | .. | .. |
| 17 Gastropods | .. | .. | .. | .. | .. | F | .. | F | C | F | .. | F |
| 18 *Balanus amphitrite* | R | F | S | C | C | C | C | C | .. | F | .. | S |
| 19 *Cirolana pleonastica* | F | .. | F | C | C | C | C | C | C | .. | .. | F |
| 20 Amphipods | F | F | S | C | C | C | C | C | C | F | F | F |
| 21 Crabs | F | .. | C | C | C | C | C | C | .. | C | .. | C |
| 22 Hermit crabs | .. | .. | F | C | C | .. | .. | C | .. | C | .. | .. |
| 23 *Penaeus sp.* | .. | .. | F | .. | .. | .. | .. | .. | F | R | .. | P |
| 24 *Membranipora sp.* | .. | F | F | .. | .. | F | F | .. | F | .. | F | C |
| 25 Alpheids | .. | .. | .. | F | .. | F | .. | .. | F | .. | .. | .. |
| 26 Gobeids | .. | .. | .. | F | .. | .. | F | F | .. | .. | .. | C |
| 27 *Palaemon sp.* | .. | .. | .. | .. | F | F | .. | F | .. | .. | .. | .. |
| 28 *Salmacis virgulata* | .. | .. | .. | .. | .. | F | .. | .. | .. | .. | .. | .. |
| 29 *Arius sp.* | .. | .. | .. | .. | .. | .. | .. | .. | .. | R | .. | .. |
| 30 *Ostrea madrasensis* | F | C | C | C | R | P | R | F | C | .. | P | S |
| **Nature of the bar** | Open. | Open. | Open. | Open. | Open. | Closed on 14th June 1957. | Closed. | Opened on 28th August 1957. | Closed on 27th September 1957. | Closed. | Opened on 4th November 1957. | Open. |

| | | |
|---|---|---|
| R | indicates | Rare. |
| F | ,, | Few. |
| C | ,, | Common. |
| P | ,, | Plenty. |
| S | ,, | Swarming. |
| .. | ,, | Nil. |

TABLE II.—*Showing the relative abundance of Organisms on the Oyster Cultch in 1958.*

| *Organisms.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 *Gracillaria sp.* | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | Cultch washed away by floods. | |
| 2 *Lyngbya sp.* | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | | |
| 3 *Entermorpha sp.* | P | C | C | .. | C | P | C | .. | .. | .. | | |
| 4 Encrusting sponges | .. | .. | .. | C | C | P | C | F | .. | .. | | |
| 5 Anemones | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | | |
| 6 Hydroids | F | C | C | .. | F | F | F | .. | .. | .. | | |
| 7 Polychaetes | R | R | F | C | S | S | C | F | C | C | | |
| 8 *Hydroides norvegica.* | C | C | S | P | P | P | C | .. | C | C | | |
| 9 *Modiolus undulatus* | .. | R | F | C | C | P | C | .. | C | R | | |
| 10 Meretrix casta | .. | .. | .. | F | R | .. | .. | .. | .. | .. | | |
| 11 *Cerithidium fluvialis* | .. | F | .. | .. | .. | .. | .. | .. | .. | .. | | |
| 12 *Lamellibranchs* | .. | .. | F | F | R | .. | .. | .. | .. | .. | | |
| 13 Nudibranchs | .. | .. | .. | F | .. | .. | .. | .. | .. | .. | | |
| 14 *Anomia sp.* | F | F | F | F | R | .. | .. | .. | .. | .. | | |
| 15 *Mytilus viridis* | .. | .. | F | F | R | .. | .. | .. | .. | .. | | |
| 16 Planarians | .. | R | R | F | C | F | .. | .. | .. | .. | | |
| 17 Gastropods | F | .. | F | .. | C | .. | .. | C | .. | .. | | |
| 18 *Balanus amphitrite* | C | C | S | C | S | P | C | C | C | F | | |
| 19 *Cirolana pleonastica* | .. | F | F | F | P | P | C | .. | C | C | | |
| 20 Amphipods | F | C | C | C | P | P | C | C | C | F | | |
| 21 Crabs | F | F | F | F | C | .. | F | F | F | .. | | |
| 22 Hermit crabs | .. | .. | .. | F | F | C | .. | C | .. | .. | | |
| 23 *Penaeus sp.* | C | C | .. | .. | .. | .. | .. | .. | .. | .. | | |
| 24 *Membranipora sp.* | P | P | C | R | R | .. | .. | .. | .. | .. | | |
| 25 *Alpheids* | C | .. | .. | .. | F | F | .. | C | .. | C | | |
| 26 *Gobeids* | .. | R | R | .. | .. | .. | .. | C | C | C | | |
| 27 *Palaemon sp.* | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | | |
| 28 *Salmacis virgulata* | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | | |
| 29 *Arius sp.* | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | | |
| 30 *Ostrea madrasensis* | S | P | C | C | F | F | R | F | R | .. | | |
| 31 Molluscan eggs | .. | .. | R | .. | .. | .. | .. | .. | .. | C | | |
| 32 *Ophiocnemis marmorata* | .. | .. | .. | .. | R | .. | .. | .. | .. | .. | | |
| 33 *Dasychone cingulatus* | .. | C | F | C | .. | | .. | .. | .. | .. | | |
| Nature of the bar | Open. | Open. | Open. | Open. | Open. | Closed on 10th June 1958. | Closed. | Closed. | Closed. | Opened on 19th November 1958. | Open. Heavy floods and rain. | Open. |

**Table III.**—*Showing Metereological and Hydrographical conditions of Ennur Backwaters from April 1957 to March 195 .*

| | *April* 1957. | *May* 1957. | *June* 1957. | *July* 1957. | *August.* 1957. | *Septem-ber.* 1957. | *October* 1957. | *Novem-ber.* 1957. | *Decem-ber.* 1957. | *Janu-ary.* 1958. | *Febru-ary.* 1958. | *March* 1958. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Average atmospheric temperature (°C.). | 31·15 | 32·80 | 32·80 | 31·15 | 30·60 | 30·00 | 29·5 | 28·9 | 28·9 | 28·4 | 28·9 | 30·6 |
| Humidity (percentage). .. | 69·00 | 79·00 | 77·00 | 74·00 | 76·00 | 80·00 | 80·00 | 84·0 | 83·0 | 80·0 | 79·0 | 89·0 |
| Rainfall (mm) .. .. | .. | 0·5 | 1·3 | 117·1 | 24·1 | 117·3 | 156·2 | 444·0 | 2·0 | 9·1 | .. | .. |
| Surface temperature (°C.) .. | 25·0 | 31·2 | 30·6 | 28·9 | 27·25 | 28·9 | 30·6 | 28·9 | 29·5 | 28·9 | 28·4 | 31·2 |
| Specific gravity .. .. | 1·024 | 1·026 | 1·026 | 1·024 | 1·013 | 1·021 | 1·005 | 1·010 | 1·021 | 1·022 | 1·023 | 1·023 |
| pH .. .. .. .. | 8·1 | 8·1 | 8·2 | 8·1 | 8·1 | 8·1 | 8·2 | 8·1 | 8·2 | 8·2 | 8·2 | 8·3 |
| Turbidity (cm.) .. .. | 24 | 56 | 45 | 44 | 39 | 45 | 60 | 46 | 46 | 58 | 66 | 63 |
| Salinity (°/1000) .. .. | 43·96 | 40·11 | 47·07 | 43·79 | 30·35 | 37·25 | 31·93 | 26·84 | 35·14 | 41·39 | 43·76 | 45·96 |
| Dissolved oxygen (cc./L.)] .. | 3·63 | 4·62 | 5·81 | 6·92 | 4·90 | 3·22 | 4·98 | 7·00 | 4·41 | 4·69 | 3·85 | 4·34 |
| Barometer reading (inches).. | 30·4 | 30·2 | 30·2 | 30·2 | 30·2 | 30·2 | 30·4 | 30·5 | 30·5 | 30·5 | 30·5 | 30·5 |
| Condition of bar .. .. | Open. | Open. | Closed. | Closed. | Open. | Closed. | Closed. | Open. | Open. | Open. | Open. | Open. |

Oyster spat are noticed from nine to eleven months in the year. There is a minor peak period in March-April and a major peak period in December-January. There is a marked decrease in spat fall soon after the bar closes in June and there is a peak period of spatfall after tides have been regulated following the reopening of the bar. A heavy mortality of 75 per cent to 95 per cent of Oysters and spat is noticed in October-November during the north-east monsoon.

*Balanus amphitrite* is present for ten months in the year. 75 to 95 per cent mortality was recorded in January, February and October, November in 1957 and in October, November, December in 1958. An abundance was noticed in March and December 1957.

*Hydroides norvegica* is available for nine to ten months. They are found in good numbers throughout these months and are particularly abundant in March, April and May.

*Modiolus undulatus* is available from eight to eleven months in the year. It is present in large numbers from April to July. Many other *lamellibranchs* are also present but *Modiolus undulatus* is most common among them. *Mytilus viridis* was present for eight months in 1957 but was available only for three months in 1954.

Crabs and hermit crabs appear commonly in March, April, May when larval organisms which form their food are in abundance.

Most organisms including the *Lamellibranchs, Gastropods,* Hydroids, Anemones, Echinoderms, Planarians and Nudibranchs are carried into the estuary with the tides in the months following the opening of the bar.

Amphipods and Isopods form almost permanent abodes in the cultch and are available almost throughout unless washed away by heavy floods during the north-east monsoons.

In general, there are two main seasons of occurrence for all estuarine organisms. Most organisms prefer the summer months of April, May, June when high temperature and corresponding high biological activity results in a rapid increase and growth of organisms. The other period is the post-monsoon period of December, January, February at the close of the north-east monsoon when the bar has been forced open and free tidal influx not only carries in larval forms but also encourages spawning of organisms. The months of July to November are unreliable months as the estuarine organisms tide over a very crucial stage in their life history. The sudden changes in hydrographical conditions due to rain and floods cause the death of settling organisms and also reduce their food supply leaving the survivors, if any, in a very poor condition.

All sedentary forms and most other settling organisms are competitors with the oyster spat for food and space. Some however like the crabs, hermit crabs and gobeids are predators, that feed on the settling oyster larvæ themselves. Certain forms like amphipods and mud-dwelling polychætes not only compete for food and space but also spoil the settling space of oyster spat by accumulating silt.

Among the competitors for food and space, the barnacle *Balanus amphitrite*, the tube dwelling polychæte *Hydroides norvegica* and the *lamellibranch Modiolus undulatus* rank first, second and third respectively in their order of importance. All three of them are present for long periods and the first two are highly resistant to unfavourable conditions. They increase very rapidly covering every inch of settling space meant for the oyster spat and even grow over the oyster spat smothering them and preventing their natural free growth by suppressing them and incidentally cutting short their food supply also.

## DISCUSSION

Certain of the marine foulers recorded by Kuriyan (1950) and Daniel (1954) have also been recorded in brackishwater. Their seasons of settling are however not the same. Thus Hydriods have been recorded throughout the year by Kuriyan, and from August to March by Daniel. In brackishwater they have been recorded from March to June and in October, December in 1957 and January to

March and May to July in 1958. Similarly *Membranipora* has been recorded as abundant in August, September by Kuriyan and as occurring in small numbers only from April to September and January to March by Daniel. In brackishwater it has been recorded in small numbers in March, April, June, July, September, November and December in 1957, and in large numbers from January to March and rarely in April, May in 1958.

*Hydroides norvegica* has been recorded by Daniel (1954) as being abundant in the teak planks exposed and not exposed to wave action within the Madras harbour during its peak period of occurrence in November, December and as being rare on the test planks exposed to the natural conditions of the open sea. This variation in the time and intensity of occurrence of the same organisms is due to several factors. Even in sea water much depends on whether the object is immersed in a sheltered position or is exposed to the currents of the open sea, whether it is subject to wave action or not and a host of other similar factors. In an estuary although the waters are sheltered other factors interfere such as drought in summer, fresh water floods during the north-east monsoon, free tidal inflow with the opening of the bar and the cessation of tides with the closing of the bar.

Further settling does not depend on prevalent hydrographical conditions alone. Daniel has recorded a certain ecological succession in the occurrence of fouling organisms, and states that this involves definite relations between organisms and is occasioned by factors of the environment some of the earlier forms being essential for preparing the substratum for the establishment of the later forms and that in Madras the primary film consisting of diatoms is followed by barnacles and tubiculous polychaetes and then polyzoans and molluscs. Besides the seasonal cycle this ecological succession is also noticeable in estuarine waters. Daniel has recorded that oyster spat suppress the growth of *Balanus amphitrite* by attaching to its sides.

In the course of the experiment it was noticed that during oyster spat fall freshly immersed cultch did not show settling while those which had been in the water for at least a week's time had a good settlement. The primary film is thus necessary for settlement but in the case of the oyster cultch it will be noticed that the swarming period of the oyster spat is only followed by the swarming period of the barnacle *Balanus amphitrite* and the tubiculous polychaete *Hydroides norvegica*. The settling of oyster spat precedes the settling of these two and not as Daniel has recorded them, preceding the settlement of polyzoans and molluscs including oyster spat.

The reason for this difference in the order of succession may be the effect of light and the colour of the substratum on the particular organism as suggested by Kuriyan and Mahadevan (1953). This may depend on the relationship the organisms bear to the cultch material as suggested by Chidambaram and Dinamoni in their experiments in 1949–50 with oyster larvæ and cultch of varying material where settlement of oyster spat on wood was found to be comparitively poor. Daniel has recorded his settling on teak planks which is probably a favourable substratum for barnacle settlement whereas the harder substratum of the country tile with its coating of calcium, probably required for the hardening of the shell of the oyster spat is preferred by the oyster and hence the quicker settlement of oyster spat preceding the barnacle settlement.

As a result of the subsequent settlement of barnacles and polychaetes which increase very rapidly when they are allowed to remain covering the settling space of the oyster spat as well as the oyster spat that have settled, the growth of the oyster spat is suppressed due to the overcrowding. Where the foulers were cleaned periodically the oyster spat showed approximately 10 mm. growth per month so that in a year's time it was possible to get healthy oysters of 90 mm. to 120 mm. size range fit for consumption.

## CONCLUSION

If the proper substratum for the collection of oyster spat is used one can be certain of getting an abundant settling of oyster spat during the favourable season when oyster larvæ are present in large numbers. The cultch should be placed just in time to get a primary film and not long enough for other organisms to settle. Once they have been collected they have to be protected in specially fenced portions in the deeper waters where they may be kept free from silt which has a smothering action. Periodical cleaning to remove silt and foulers without damage to the spat must be a part of the programme as it will ensure a good crop of well fattened oysters for the year. The later settlement of the foulers, especially the three main competitors of food, settling space and growing space of the oyster spat, namely, *Balanus amphitrite*, *Hydroides norvegica* and *Modiolus undulatus*, respectively enable one to eradicate them more easily than would otherwise have been possible.

The study of the fouling organisms on the edible oyster cultch throws light on the habits and inter-relationship of these organisms with the oyster spat and opens up a new vista in the annals of edible oyster farming. Careful and methodical preparation of suitable cultch, collection during the precise time, rearing of the spat, keeping the mortality rate as low as possible on the basis of the knowledge gathered on the edible oyster spat and their associations, will ensure a maximum production of oysters fit for the table in one year. As there are two peak periods of oyster spat settlement it will be possible to get two harvests of full grown oysters annually.

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# SWARMING OF THE BRITTLE STAR, OPHIOCNEMIS MARMORATA (LAMARCK) IN THE ENNUR BACKWATERS

BY

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## INTRODUCTION

The Brittle star, *Ophiocnemis marmorata* (Lamarck) is of common occurrence in the shore-seine catches along the Madras Coast. Gravely (1941) mentions its occurrence commonly on the sandy sea bottom of the Madras Coast and its availability in the fishing nets brought ashore. Chacko, Abraham and Andal (1953) have recorded this Ophuiroid as living attached to the frilled oral arms of the jelly fish *Acromitus flagellatus* (Haeckel) in the Pulicat lake, which is a brackishwater swamp that has several connections with the Bay of Bengal. Panikkar and Prasad (1952) mention that of several specimens of the *Scyphomedusae*, *Rhopilema hispidum Maas* observed by them in June-July 1950 very near the shore in Palk Bay, ten live specimens were collected with innumerable specimens of *Ophiocnemis marmorata* in association with them.

## OBSERVATIONS

The Ennur backwater is the estuary of the Kortalaiyar river. This brackish water area is in connection with the Bay of Bengal for at least six months in the year, between October of the one year to April of the succeeding year. Even though, daily hydrographical and biological observations were made in this estuary since May 1955 there were no instances of collection of *Ophiocnemis marmorata*. But on 24th April 1958, there was phenomenal swarming of this brittle star to a distance of one mile up the river. They were found in clusters one on top of the other on floating pieces of wood overgrown with *Balanus amphitrite* and on drifting clumps of live filamentous algæ (predominantly of Enteromorpha) and clinging in masses to the sub-umbrellar surface and oral arms of every live specimen of the jelly fish *Acromitus flagellatus* (Haeckel) available at the time. The ophuiroids were small measuring from 2·5 cm. to 5 cm. diametrically from arm-tip to arm-tip. The appearance of the jelly fish in the backwater was however not sudden and they were already available in swarms at the time. Young stages of these jelly fish of less than one centimetre diameter had been available in the estuary since December 1957 ; these had grown into adult forms 15 to 30 cm. in diameter. It was interesting to note that it was not possible to obtain a single specimen of the jelly fish that was not infested by the ophuiroid. Each jelly fish harboured not less than fifty ophuiroids and in some there were as many as a thousand. The association which was first noticed on 24th April 1958 continued till 30th April 1958 after which the disappearance was as sudden as the appearance.

Besides *Acromitus flagellatus* specimens of *Chrysaora helviola var calliparea* (*Dactylometra quinquienha*) were also available in the estuary at the time. These had entered the estuary at the beginning of April 1958 from the sea and were available till the end of May 1958 in the ratio of one to every hundred of *Acromitus*. The ophuiroid was not found in association with *Chrysaora helviola* in any instance.

A study of the meteorological and hydrographical conditions, before, during and after the incident was made. The bar was open throughout and there was free tidal inflow. New moon was on 19th April 1958, five days before the swarming occurred. Tides were higher during this period than the usual and the sea was rough. Full moon followed on 3rd May 1958, three days before which the ophuiroids disappeared. Cloudy weather and rain followed the full moon.

Meteorological and hydrographical ranges for the period 15th April 1958 to 7th May 1958 were as follows :—

Humidity.—76–92 per cent.  
Maximum atmospheric temperature—27·8–32·2° C.  
Minimum atmospheric temperature—26·8–31·1° C.  
Barometer reading—30·3–30·5 inches.  
Transparency—63–78 cm.  
Specific gravity—1·022–1·024.  
Surafce water temperature—27–32·8 °C.  
PH.—8·0–8·3.  
Dissolved oxygen—1·75–4·83 cc./L.  
Salinity—33·94–44·46. °/°°

The sky was clear till 3rd May 1958 after which it was cloudy. Rain of 0·65 and 2·2 inches was recorded on the 6th and 7th May 1958, respectively.

Meteorological and hydrographical conditions on 24th April 1958 when the phenomenon occurred were as follows:-

Maximum atmospheric temperature—31·7° C.  
Minimum atmospheric temperature—30·6° C.  
Humidity—92 per cent.  
Barometer reading—30·4 inches.  
Transparency—74 cm.  
Specific gravity—1·024.  
Surface water temperature—31·1° C.  
pH.—8·2.  
Dissolved oxygen contents—3·15 cc/L.  
Salinity—43·22.° /°°  
Sky—Clear.

A study of the readings showed that they were all higher than the minimum values recorded for the period, the increase being gradual. Humidity alone which was 76 per cent on the 23rd April 1958 shot up to 84 per cent on the 25th April 1958 and further to 92 per cent on the 25th April 1958 at which it remained for the period of the phenomenon till 2nd May 1958.

Three of the *Acromitus* carrying between 300 to 400 ophuiroids were put into the topmost crate of an oyster box fixed in the estuary for oyster spat collection on the 25th April 1958. The crate contained bent limed country tiles, used as cultch. The tiles were arranged in tiers each tier alternating in direction with the previous tier being placed at right angles to each other and forming an adequate system of channels for the free inflow and outflow of water. The crate was re-examined the following month on the 27th May 1958 when it was noted that the jelly fish had probably died in confinement and had disintegrated only to be washed away by the current, and that only three specimens of *Ophiocnemis marmorata* remained. They were obtained from three different tiles in a healthy and well-fed condition. They measured 7 cm. diametrically, the growth in one month being 2 cm. at least.

The ophuiroids were not found in the natural estuarine conditions after this. They were however occasionally obtained from the sea. On 11th June 1958 a small specimen 2·5 cm. in diameter was found partly engulfed by a *Sphenopus* which was cast ashore. A week later a still smaller specimen, 1 cm. in diameter, was found washed ashore in an old cycle tyre.

## DISCUSSIONS

The association of the Ophuiroid *Ophiocnemis marmorata* with the backwater jelly fish, *Acromitus flagellatus* (Haeckel) seems to be one of temporary commensalism. The normal habitat of the ophuiroids is the sea-bottom where they feed upon the minute organisms and organic matter contained in the surface mud. Their occurrence in the estuary is possible as the bar was open during the period of the incident, facilitating tidal ingress and egress and with it the migration of animals to and from the sea. The occurrence of the ophuiroid on floating masses of wood and algæ also, make it clear, that the *Acromitus* were used in the course of events as harmless objects of shelter available in the surface layers of water at the time. Their inavailability on *Chrysaora helviola* also found in the surface water at the time, makes this even more obvious. *Chrysaora* has been intentionally avoided because of the terrible effect of its powerful sting.

The phenomenon took place five days after new moon when tides were still high and the sea still turbulent. There is every possibility that violent current and churning of the bottom of the sea due to the turbulence had brought these forms to the surface as stated by Chacko (1942) or that upwelling and vertical circulation as described by La Fond 1954 and 1955 and La Fond and Bhavanarayana (1957) which is nothing uncommon on the east coast of India was responsible for the unusual incident. *Acromitus flagellatus* present in large numbers at the time, migrating in and out of the estuary lent very timely assistance in harbouring these homeless arrivals in their harmless protective sub-umbrellar surfaces. This association may as Panikkar and Prasad (1952) have noted help the ophuiroid to get distributed over a wide area.

The sudden disappearance of the ophuiroid is as amazing as their appearance. It is quite possible that they had returned to their normal habitat although many thousands perished by being washed ashore along with their algal or wooden rafts or by being dragged ashore by fishing nets. The survival and growth of the three ophuiroids in the oyster crate suggest the escape of many hundreds in a similar way. The occurrence of stray specimens of young Ophuiroids from the sea even after the incident show that they were not only present but were breeding in their natural habitat on the sea bottom once again.

This interesting association of the ophuiroid *Ophiocnemis marmorata* with the backwater jelly fish *Acromitus flagellatus* (Haeckel) is undoubtedly one of temporary commensalism where the jelly fish offers shelter and also remnants of the food it feeds on, enabling the ophuiroid to tide over adverse conditions.

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# ON A SURVEY OF THE PEARL BANKS OF TUTICORIN, GULF OF MANNAR, IN 1961-62

By

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## INTRODUCTION

The Pearl Banks of Tuticorin number about fifty-two extending from Vaipar periyapar in the north to Manapad periyapar in the south [Hornell (1922)]. Recently seven pearl fisheries have been conducted continuously from 1955 to 1961 as shown in Table I.

Table I.

*Showing details of pearl fisheries from* 1955 to 1961.

| *Year.* | *Pearl banks exploited.* | *Total number of oysters fished.* | *Total revenue by Government.* |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| | | RUPEES IN LAKHS. | |
| 1955 | Thollayiram par<br>Saithonpathu par<br>Kuthadiar par. | 35 | 1·3 |
| 1956 | Thollayiram par | 21 | 0·4 |
| 1957 | Do.<br>Kodamuthi par<br>Saithkudamuthu par | 111 | 1·6 |
| 1958 | Rajavukkusippi<br>sothicha par<br>Karuval par | 215 | 4·6 |
| 1959 | .. | 164 | 8·0 |
| 1960 | .. | 168 | 2·2 |
| 1961 | .. | 154 | 2·9 |

With a view to ascertain the particulars of pearl oyster population and the ecology of the banks a survey was conducted from December 1961 to February 1962; and the observations made are reported in this paper.

The following ten main productive banks (Fig. 1) were surveyed :—

1 North Thollayiram par
2 Karaikeluthi par
3 South Thollayiram par
4 Kudamuthi par
5 Sultan par
6 Nadumalaipiditha par
7 Periyamalaipiditha par
8 Karuval par
9 Thiruchendur poonthottam par
10 Manapad periyapar

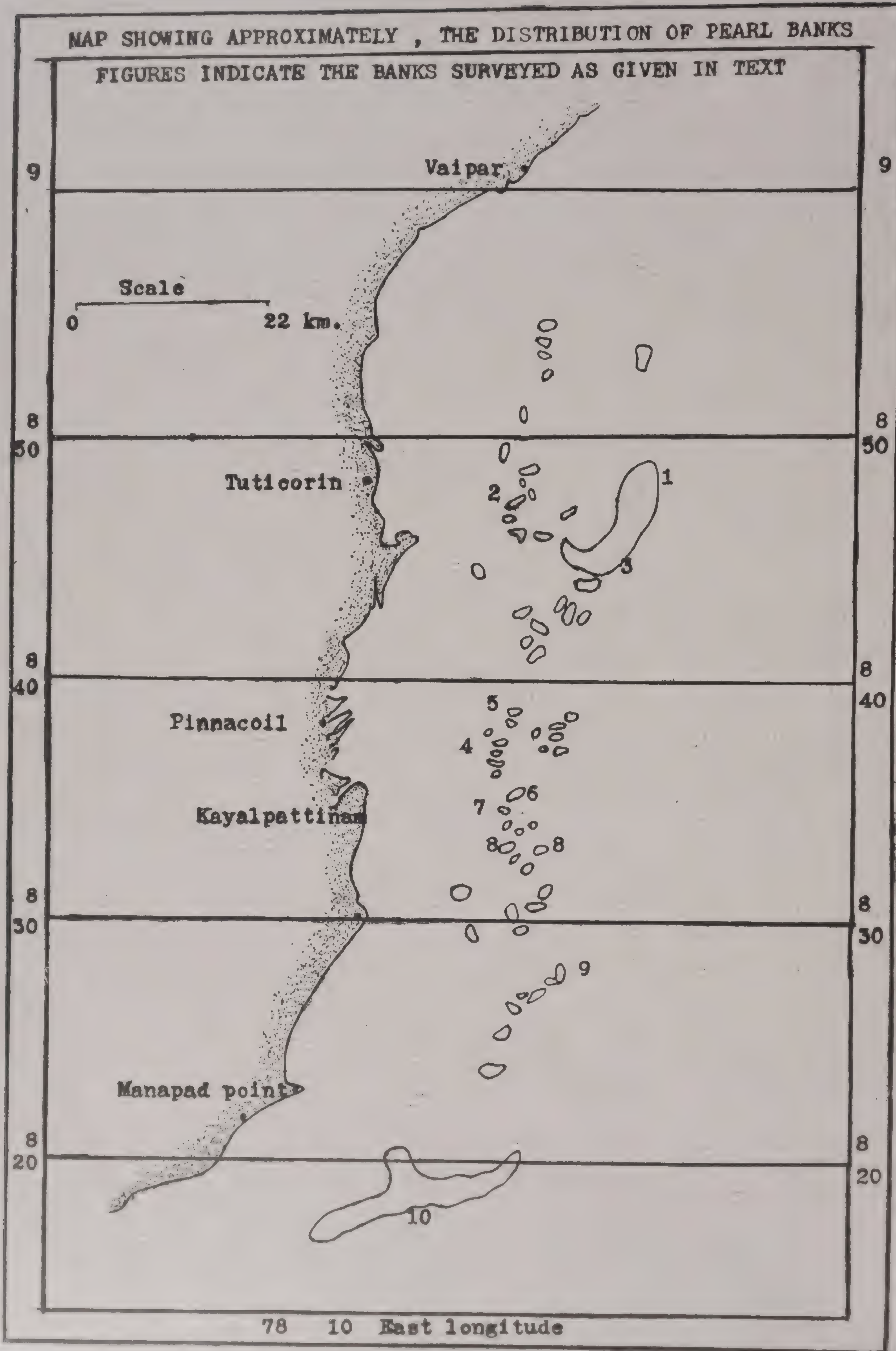
The programme of survey was divided into three phases. In the first phase a preliminary survey was conducted of the first nine pars with the assistance of skin-divers. In the second phase aqua-lung diving and skin-diving were used in a detailed survey of the pars where oysters were detected during the preliminary survey. In the third phase the Manapad periyapar was surveyed with aqua-lung alone. As this par was far off from Tuticorin a separate camp was established at Manapad village for this purpose.

## EQUIPMENT AND METHODS

Two canoes with two skin-divers in each were employed. A Paramantadi (professional pilot) located the banks. Two departmental officers (Sri Isaac Rajendran and Sri Kanakaraj David) equipped with aqua-lungs conducted the second phase of the programme along with the skin-divers. During the third phase Sri K. Nagappan Nair and Sri S. Mahadevan, Assistant Research Officers of the Central Marine Fisheries Research Unit, joined the party by using aqua-lungs. The departmental launch M.F.V. Goherkaleeli was summoned for this purpose. But this vessel went out of order on 19th December 1961 and thereafter the offshore fishing vessel (M.L. Sardinella) of the Government of India, skippered by Sri Hameed was used in the first phase. During the second and third phases two thirty-footer mechanised Pablo boats were used as survey vessels. The fauna, flora, depth, nature of bottom, number of oysters in each dive, etc., were all noted in a data sheet. Oysters when present were stored in tin containers and brought to the laboratory for age determination. The oysters were then put in mud pots, sealed and allowed to rot for determining their pearl content.

## RESULTS

Oysters were found to exist only in three areas, namely, North Thollayiram par, Karaikeluthi par, and South Thollayiram par. Oysters were not found in the other seven pearl banks examined during the survey. The summary of the daily operations are shown in Appendix I the fauna and flora frequencies in Appendix II, the length frequency distribution of random samples of oysters in Appendix III, and details of depth and nature of bottom in Appendix IV.



MAP SHOWING APPROXIMATELY , THE DISTRIBUTION OF PEARL BANKS

FIGURES INDICATE THE BANKS SURVEYED AS GIVEN IN TEXT

Fig.1.

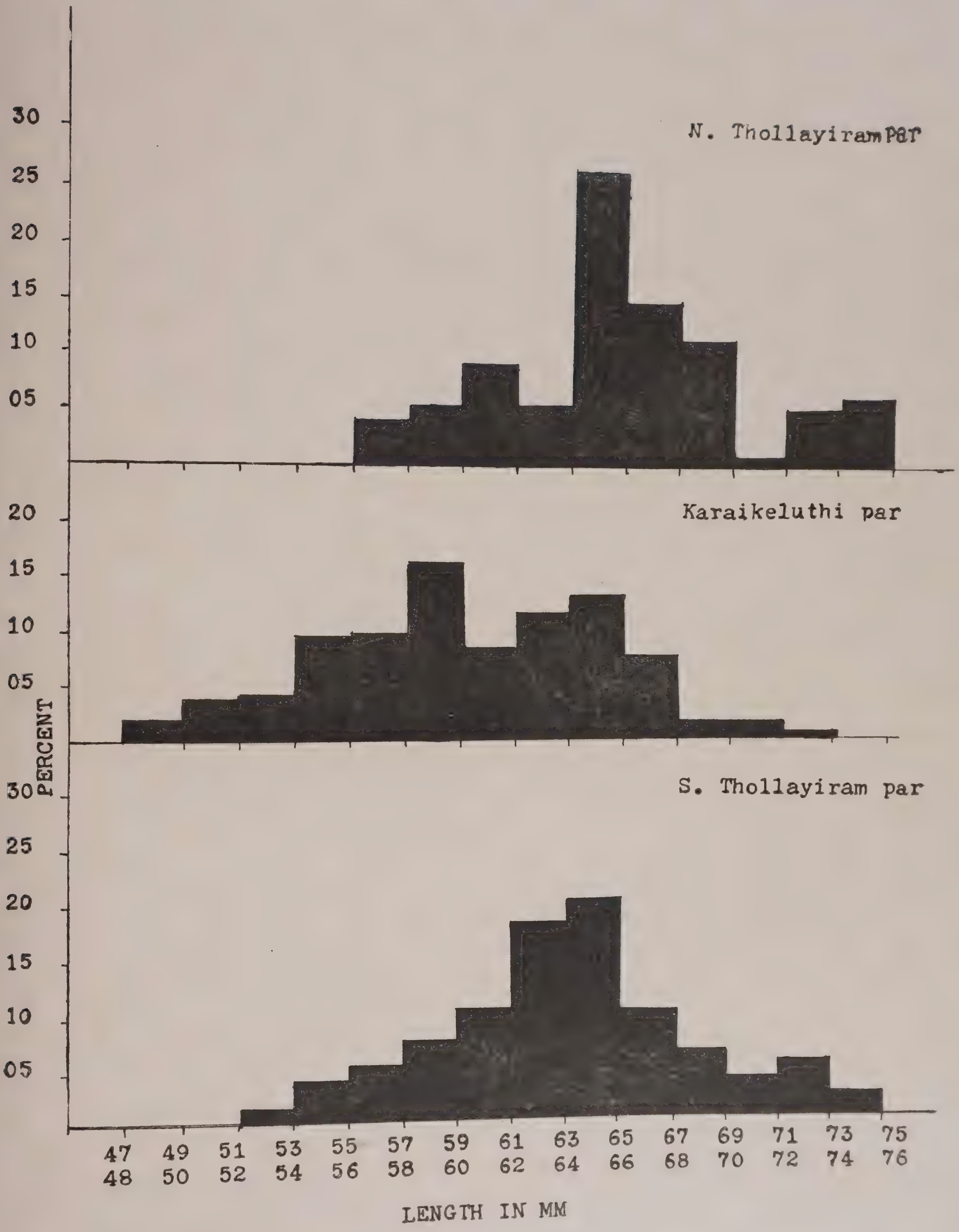


Fig.2. Showing length frequency of pearl oysters of the three pars

The number of oysters brought up by the skin divers in the first and second phases of the programme, in the three areas mentioned above and the catch-per-unit effort are shown in Table II.

TABLE II.

*Showing the catch-per-unit effort of diving.*

| *Name of pearl bank.* (1) | *Total number of oysters brought up by divers.* (2) | *Number of dives made.* (3) | *Catch per unit effort of diving.* (4) |
|---|---|---|---|
| 1. N. Thollayiram par— | | | |
| (*a*) First phase .. | 352 | 264 | 1·3 |
| (*b*) Second phase .. | 173 | 80 | 2·2 |
| 2. Karaikeluthi par— | | | |
| (*a*) First phase .. | 186 | 126 | 1·4 |
| (*b*) Second phase .. | 58 | 92 | 0·9 |
| 3. S. Thollayiram par— | | | |
| (*a*) First phase .. | 122 | 104 | 1·1 |
| (*b*) Second phase .. | 73 | 53 | 1·4 |

## AGE COMPOSITION OF THE OYSTERS

Devanesan and Chidambaram (1956) studied the growth rates of pearl oysters reared in cages in the pearl farm of the Marine Biological Station, Krusadi Island, and arrived at a hypothetical size composition of a random sample of thousand oysters from an imaginary bed, based on shell length and body weight. The age of oysters obtained during the present survey was determined using the following data arrived at by the above authors, for the average shell length value.

| *Age.* | *II year.* | *III year.* | *IV year.* | *V year.* |
|---|---|---|---|---|
| Average shell length. | 57 mm. | 63 mm. | 61 mm. | 64 mm. |

The length frequency distribution of oysters collected at N. Thollayiram par, Karaikeluthi par and S. Thollayiram par are also shown as histogram in Fig. 2.

From the histogram it is seen that the majority of oysters collected from N. Thollayiram par are of the size group 63–64 and 65–66, corresponding to the ages three and five years. In S. Thollayiram par besides the above groups another group also shows predominance, i.e., 61–62 corresponding to four years. In the case of Karaikeluthi it is more difficult to interpret. The vast majority of oysters are of the size group 57–58 and 59–60, corresponding to two and perhaps two and a half years. A good percentage also belong to the size groups 61–62, 63–64 and 65–66, corresponding to three, four, five, and perhaps of more than five years. It can also be noted that in the case of Thollayiram par, north and south sections, the distribution of length measurements of oysters is unimodal, whereas in Karaikeluthi it is bimodal.

## ESTIMATION OF POPULATION

Hornell (1922) assumed that the area covered by a diver per dive to be three square yards. According to this 792 square yards (264 × 3) were covered and got 352 oysters in the first phase (Table II) at N. Thollayiram par. This works out to less than one oyster per square yard. In the second phase 173 oysters were obtained from 240 (80 × 3) square yards. This also works out to less than one per square yard. Similarly it is seen that the oyster population in the Karaikeluthi and S. Thollayiram pars to be less than one per square yard, showing thereby that the oyster population is very thin. The majority of oysters in the North and South Thollayiram pars being of an older generation may perish shortly, as the maximum life span of an oyster is about five years. Some oysters may be left over at Karaikeluthi as they are of a younger generation.

## DISCUSSION

From the earliest times it has been noticed that there is irregularity in the occurrence of pearl fishereis of the Gulf of Mannar. Thus in his "History of East Indies" Velentyn quotes Governor Van Goens' Memoir, dated 1663 A.D. that "the banks of Gulf of Mannar (Island of Mannar) have given no profit, although the revenue from them was once most considerable...... " Arunachalam (1952). It has also been found that the Indian Fishery was preceded by the Ceylon Fishery by two or three years. Whereas pearl fishery is annual in the Persian Gulf, it is intermittent in character in the Gulf of Mannar. Long interval of barren periods occurring between two fisheries. From 1930 till 1954 for over twenty years the pearl banks have been barren. It was only from 1955 to 1961 there had been continuous annual fishery in the Indian coast. Chacko and Rajendran (1955) have given an account of the gross revenue of pearl fisheries from 1663. It is seen from this that there had been only 32 pearl fisheries from 1663 to 1928. Hornell (1916) attaches much importance to fish enemies of oysters as the principal factor in the economy of the Indian pearl fisheries. He has witnessed the total destruction by predatory fishes, within a brief period of few weeks, of immense beds of young oysters in the Gulf of Mannar. He has concluded "when beds of oysters do come to maturity in spite of all dangers which have beset them the state should fish them vigorously and accept the proceeds windfall of revenue. Chacko (1959) found oyster shells in the stomach contents of *Abalistes stellaris*, thus strengthening the view of Hornell.

Devanesan and Chidambaram (1956) cited three main causes for this periodicity in the occurrence of pearl fisheries, namely, (1) over fishing, which upsets the balance of biological laws of environment, (2) the probable preponderence of females and the paucity of males and (3) the inability of scattered ripe females to produce necessary stimulus to the ripe males to induce them to eject their spawn on account of their separation by long distances from the nearest male. They pointed out that after every pearl fishsery there is inevitably a complete collapse and that rebuilding takes time, sometimes running to thirty years. From facts shown in Table I the above statement cannot be accepted completely but if the seven pearl, fisheries from 1955 to 1961 are considered as a single unit it may be possible to find a probable explanation for the present barren condition of the pearl banks off Tuticorin.

## ACKNOWLEDGMENTS

I am greatly indebted to Sri P. I. Chacko, Assistant Director of Fisheries, Information and Marine Biology, Madras, and Sri S. H. Hussainy, Assistant Director of Fisheries, Tuticorin, for guidance and facilities given to me during this survey.

## SUMMARY

1. A survey of ten important productive pearl banks of the central sector of the Gulf of Mannar was conducted

from 14th December 1961 to 28th February 1962 with skin-divers and aqua-lung equipment.

2. Oysters were found to be very thinly populated in the three areas, namely, N. Thollayiram, Karaikeluthi and S. Thollayiram pars.

3. The oysters collected belonged to third and fifth year classes at N. Thollayiram par, and third, fourth and fifth year classes at S. Thollayiram par, but they were found to be of a mixed population at Karaikeluthi par.

4. The probable causes for this condition of the pearl banks are discussed.

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### APPENDIX I.

*Summary of skin-diving operations carried out during the pearl bank survey* 1961–62.

| *Date.*<br>(1) | *Name of par.*<br>(2) | *Number of dives made.*<br>(3) | *Number of oysters.*<br>(4) |
|---|---|---|---|
| | *I phasv.* | | |
| 14th Decembar 1961 | Thollayiram par, N. | 46 | 44 |
| 18th December 1961 | Do. | 150 | 174 |
| 2nd January 1962 | Do. | 68 | 134 |
| 5th January 1962 | Karaikeluthi, par | 72 | 86 |
| 6th January 1962 | Thollayiram par, S. | 104 | 122 |
| 8th January 1962 | Kudamuthi par, | 32 | No oysters. |
| 10th January 1962 | Sultan par, | 64 | Do. |
| 11th January 1962 | Kudamuthi par, | 52 | Do. |
| 12th January 1962 | Karaikeluthi par, | 54 | 100 |
| 16th January 1962 | Nadumalaipiditha par | 44 | No oysters. |
| 17th January 1962 | Periyamalaipiditha par | 50 | Do. |
| 18th January 1962 | Karuval par | 48 | Do. |
| 19th January 1962 | Do. | 46 | Do. |
| 20th January 1962 | Do. | 36 | Do. |
| 22nd January 1962 | Tiruchendur poonthottam par | 36 | Do. |
| 23rd January 1962 | Do. | 42 | Do. |
| 24th January 1962 | Do. | 48 | Do. |
| | *II phase.* | | |
| 19th February 1962 | Thollayiram par, N. | 80 | 173 |
| 20th February 1962 | Karaikeluthi par | 62 | 58 |
| 22nd February 1962 | Thollayiram par, N. | 100 | 196 |
| 23rd February 1962 | Do. | 120 | 504 |
| 24th February 1962 | Do. | 128 | 73 |
| 26th February 1962 | Thollayiram par, S. | 53 | 181 |
| 27th February 1962 | Do. | 140 | 21 |
| 28th February 1962 | Do. | 70 | .. |

## APPENDIX II.

*Showing the flora and fauna frequencies of the ten pars surveyed in 1961-62.*

—Absent.

0 Very poor.

00 Rich.

000 Very rich.

| *Flora and Fauna frequency.* | *N.Thol-layiram par.* | *Karai-keluti par.* | *S.Thol-layiram par.* | *Kuda-muthi par.* | *Sultan par.* | *Nadu-malai piditha par.* | *Periya-alaim piditha par.* | *Karuval group.* | *Tiru-chendur poontho-ttam par.* | *Manapad peryaikay.* |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| *Algæ—* | | | | | | | | | | |
| *Caulerpa sp.* .. .. | — | — | — | — | — | — | — | — | 0 | — |
| *Halimeda* .. .. | — | — | 0 | — | — | — | — | — | — | 0 |
| *Spathoglossum* .. | — | 0 | — | — | — | — | — | — | — | — |
| *Ulva sp.* .. .. | — | — | 0 | — | — | — | — | — | — | 00 |
| *Padina sp.* .. .. | — | 0 | 0 | — | — | — | — | 00 | 0 | — |
| *Sargassum sp.* .. | 0 | — | 0 | 000 | — | 00 | 0 | 000 | 000 | — |
| *Gracilaria sp.* .. | 0 | — | — | — | — | 0 | — | 0 | 0 | — |
| *Porifera—* | | | | | | | | | | |
| *Aulospongus* .. .. | 0 | — | 0 | 00 | 0 | — | 00 | 0 | 000 | — |
| *Phakeila* .. .. | — | — | 0 | 0 | 0 | — | — | 00 | — | 00 |
| *Raspailia* .. .. | 00 | 0 | — | 0 | 000 | 00 | — | 0 | 00 | — |
| *Megalopastas* .. | 0 | — | 00 | — | 00 | — | — | 0 | — | 00 |
| *Coelenterata—* | | | | | | | | | | |
| *Alcyonium* .. .. | — | — | — | — | — | — | — | 0 | 00 | — |
| *Lytocarpus* .. .. | — | — | — | — | — | — | — | — | — | 00 |
| *Madreporarians* .. | 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 00 | — |
| *Arthropoda—* | | | | | | | | | | |
| *Balanus* .. .. | — | — | — | — | — | 0 | 0 | — | — | — |
| *Mollusca—* .. | | | | | | | | | | |
| *Xancus* .. .. | 0 | — | 00 | 00 | — | 0 | 00 | 0 | — | — |
| *Modiola* .. .. | 0 | — | — | — | 000 | — | — | — | 00 | 0 |
| *Pteria chinensis* .. | — | — | — | — | — | — | — | — | — | — |
| *Echinodermata—* | | | | | | | | | | |
| *Crinoids* .. .. | — | — | — | — | — | — | — | 0 | — | — |
| *Pentaceros* .. .. | 0 | 0 .. | 00 | 0 | — | 00 | — | 00 | 00 | — |

## APPENDIX III.

*Length frequency distribution of random samples of oysters (P. Vulgaris) collected from the pearl banks of Tuticorin in 1961–62.*

| *Length in mm.* | *N.Thollayiram.* | | *Karaikeluthi.* | | *S.Thollayiram.* | |
|---|---|---|---|---|---|---|
| | *Frequency.* | *Percentage.* | *Frequency.* | *Percentage.* | *Frequency.* | *Percentage.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 27–28 .. | 1 | 0·4 | .. | .. | .. | .. |
| 29–30 .. | 1 | 0·4 | .. | .. | .. | .. |
| 30–32 .. | 1 | .. | .. | .. | .. | .. |
| 33–34 .. | .. | 04 | .. | .. | .. | .. |
| 35–36 .. | .. | .. | .. | .. | .. | .. |
| 37–38 .. | .. | .. | .. | .. | .. | .. |
| 39–40 .. | .. | .. | 1 | 0·5 | .. | .. |
| 40–42 .. | .. | .. | .. | .. | .. | .. |

## APPENDIX III—*cont.*

*Length frequency distribution of random samples of oysters (P. Vulgaris) collected from the pearl banks of Tuticorin in* 1961–62—cont.

| Length in mm. | *N. Thollayiram.* | | *Karaikeluthi.* | | *S. Thollayiram.* | |
|---|---|---|---|---|---|---|
| | *Frequency.* | *Percentage.* | *Frequency.* | *Percentage.* | *Frequency.* | *Percentage.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 43–44 .. | .. | .. | 1 | 0·5 | .. | .. |
| 45–46 .. | 1 | 0·4 | .. | .. | .. | .. |
| 47–48 .. | .. | .. | 3 | 1·6 | .. | .. |
| 49–50 .. | 1 | 0·4 | 6 | 3·2 | .. | .. |
| 51–52 .. | .. | .. | 7 | 3·7 | 1 | 1 |
| 53–54 .. | .. | .. | 17 | 9·1 | 3 | 3 |
| 55–56 .. | 9 | 3·7 | 18 | 9·7 | 2 | 2 |
| 57–58 .. | 12 | 5 | 30 | 16·2 | 5 | 5 |
| 59–60 .. | 22 | 9·1 | 25 | 13·5 | 7 | 7 |
| 61–62 .. | 16 | 6·6 | 12 | 8·1 | 10 | 10 |
| 63–64 .. | 13 | 5·3 | 21 | 11·3 | 18 | .. |
| 65–66 .. | 64 | 26·6 | 24 | 12·7 | 20 | .. |
| 67–68 .. | 36 | 15 | 11 | 7·4 | 10 | .. |
| 69–70 .. | 28 | 11·6 | 2 | 1·3 | 6 | .. |
| 71–72 .. | 2 | 0·7 | 2 | 1·3 | 4 | .. |
| 73–74 .. | 12 | 5·0 | 1 | 0·5 | 5 | .. |
| 75–76 .. | 15 | 6·2 | 2 | 1·3 | 2 | .. |
| 77–78 .. | 4 | 1·6 | 1 | 0·5 | 3 | .. |
| 79–80 .. | 1 | 0·4 | 1 | 3·5 | 3 | .. |
| 81–82 .. | .. | .. | .. | .. | 1 | .. |
| 83–84 .. | 1 | 0·4 | .. | .. | .. | .. |
| | 240 | | 185 | | 100 | |

## APPENDIX IV.

*Details of depth and nature of bottom of pars surveyed in* 1961–62.

| *Date.* | *Station number.* | *Depth in fathoms.* | *Nature of bottom.* | *Name of par.* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| 14th December 1961 .. .. .. .. | 5 | 9½ | Sand over rock. | N.Thollayiram. |
| 18th December 1961 .. .. .. .. | 12 | 9–9½ | Do. | Do. |
| 2nd January 1962 .. .. .. .. | 30 | 10½ | Flat rock. | Do. |
| 5th January 1962 .. .. .. .. | 45 | 10½ | Do. | Karaikeluthi. |
| 6th January 1962 .. .. .. .. | 60 | 9 | Do. | S.Thollayiram. |
| 8th January 1962 .. .. .. .. | 72 | 7¾–8¼ | Do. | Kudamuthi. |
| 10th January 1962 .. .. .. .. | 79 | 9 | Sand over rock. | Sultan. |
| 11th January 1962 .. .. .. .. | 87 | 8 | Do. | Kudamuthi. |
| 12th January 1962 .. .. .. .. | 99 | 11 | Flat rock. | Karaikeluthi. |
| 16th January 1962 .. .. .. .. | 107 | 8–9 | Sandy. | Nadumalaipiditha. |
| 17th January 1962 .. .. .. .. | 117 | 9 | Do. | Periyamalaipiditha. |
| 18th January 1962 .. .. .. .. | 125 | 9 | Flat rock. | Karuval. |
| 19th January 1962 .. .. .. .. | 134 | 10 | Sand over rock. | Do. |
| 20th January 1962 .. .. .. .. | 145 | 9 | Do. | Do. |
| 22nd January 1962 .. .. .. .. | 150 | 8–9 | Do. | Tiruchendur poonthottam. |
| 23rd January 1962 .. .. .. .. | 157 | 8½ | Coral on rock. | Do. |
| 24th January 1962 .. .. .. .. | 165 | 9½ | Flat rock. | Do. |

# A NOTE ON THE SHRINKAGE OF THE PERIOSTRACUM OF THE SACRED CHANK, XANCUS PYRUM, ON STORAGE

BY

P. I. CHACKO, S. T. CHARI AND P. JAYACHANDRAN.

The Sacred Chank *Xancus pyrum* contributes to a very important shell fishery along the coast of Madras State. It is abundant in the Gulf of Mannar. The chank fishery is State-owned; and on an average ten lakhs of shells are fished annually fetching a revenue of about 12 lakhs rupees. About 2,000 divers and their families depend on this fishery.

The population of chanks are exploited under strict supervision. In order to perpetuate the fishery, chanks of a diameter below 2¼ inches (57·150mm.) are prohibited from fishing. Though there are several practical difficulties especially when the fishery is conducted in the sea about 16 to 20 kilometres from the shore where the depth is about 20 metres, the effect of enforcement of this regulation is beneficial.

The chanks are used to make ornaments like bangles, rings, pendants, etc., and several types of curios. At present, the chank bangle industry is located almost entirely in Bengal. Therefore the chanks fished every year have to be stored in godowns for periods extending to five years till they are transported and marketed in Bengal. It has been expressed by the traders that the chanks are likely to get reduced in size during the period of storage. A study of this aspect has been conducted with the following results:—

The chank proper has such a hard shell that there is no shrinkage at all. But the external chitinous layer periostracum, gets dried and peeled off on storage. The effect of this has therefore been noted. A sample of 80 chanks of different sizes from lots of freshly captured chanks and of various periods of storage (one to three years) was collected from the chank godowns at Tuticorin and measured for their length and diameter and thickness of the periostracum. The thickness of the periostracum was measured by the optic lever method. The data are furnished in Table I.

The thickness of the periostracum ranged from 0·33 mm. to 0·080 mm. The percentage composition of the chanks samples with reference to the thickness of the periostracum is as follows :—

| *Thickness of periostracum mm.* (1) | *Number of chanks in sample.* (2) | *Percentage to total number of chanks in sample.* (3) |
|---|---|---|
| 0·080 .. .. .. | 1 | 1·25 |
| 0·070—0·079 .. .. | 16 | 20·00 |
| 0·060—0·069 .. .. | 9 | 11·25 |
| 0·050—0·059 .. .. .. | 27 | 33·75 |
| 0·040—0·349 .. .. | 19 | 23·75 |
| 0·030 0·039 .. .. | 8 | 10·00 |

It is seen that chanks with 0·050—0·059 mm. thick periostracum are maximum, followed by 0·40—0·049 mm. group and that 0·050 mm. is the average thickness of periostracum of chank of varied durations of storage.

The periostracum shows maximum thickness of 0·080 mm. when the chank is quite fresh. The minimum thickness after long storage and shrinkage is 0·030 mm. The reduction in thickness is thus 0.050 mm. Consequently the maximum reduction in the diameter of a chank is 0·100 mm. provided the periostracum is peeled off. This is a very negligible shrinkage and does not affect the overall diameter of the chank. Even in the rare cases when the periostracum gets peeled off after very prolonged period of storage, the reduction in the diameter of a chank which originally possessed a periostracum of the maximum thicknesses of 0·080 is only 0·160 mm. This also is very negligible. Thus, practically there is no possibility of chanks getting reduced in size due to storage and thereby lowering the commercial value of the shells.

TABLE I.

*Showing length and diameter of shell and thickness of periostracum of 80 chanks.*

| *Serial number.* (1) | *Length mm.* (2) | *Diameter mm.* (3) | *Thickness of periostracum mm.* (4) |
|---|---|---|---|
| 1 | 165 | 83 | 0·075 |
| 2 | 153 | 82 | 0·072 |
| 3 | 170 | 90 | 0·073 |
| 4 | 140 | 75 | 0·040 |
| 5 | 165 | 80 | 0·045 |
| 6 | 179 | 90 | 0·050 |
| 7 | 145 | 75 | 0·060 |
| 8 | 120 | 70 | 0·050 |
| 9 | 155 | 83 | 0·035 |
| 10 | 175 | 90 | 0·030 |
| 11 | 135 | 72 | 0·037 |
| 12 | 145 | 75 | 0·039 |
| 13 | 110 | 55 | 0·042 |
| 14 | 115 | 56 | 0·045 |
| 15 | 120 | 71 | 0·050 |
| 16 | 130 | 71 | 0·072 |
| 17 | 125 | 71 | 0·075 |
| 18 | 180 | 90 | 0·050 |
| 19 | 150 | 74 | 0·055 |
| 20 | 155 | 83 | 0·052 |
| 21 | 140 | 75 | 0·062 |
| 22 | 120 | 69 | 0·073 |
| 23 | 170 | 85 | 0·076 |
| 24 | 173 | 87 | 0·078 |
| 25 | 110 | 60 | 0·080 |
| 26 | 130 | 71 | 0·042 |
| 27 | 112 | 62 | 0·035 |
| 28 | 115 | 64 | 0·038 |
| 29 | 113 | 61 | 0·045 |
| 30 | 125 | 70 | 0·047 |

TABLE I—*cont.*

*Showing length and diameter of shell and thickness of periostracum of* 80 *chanks*.—cont.

| *Serial number.* (1) | *Length mm.* (2) | *Diameter mm.* (3) | *Thickness of periostracum mm.* (4) | *Serial number.* (1) | *Length mm.* (2) | *Diameter mm.* (3) | *Thickness of periostracum mm.* (4) |
|---|---|---|---|---|---|---|---|
| 31 | 119 | 65 | 0·049 | 56 | 142 | 73 | 0·072 |
| 32 | 134 | 75 | 0·050 | 57 | 118 | 57 | 0·055 |
| 33 | 149 | 75 | 0·032 | 58 | 119 | 53 | 0·045 |
| 34 | 129 | 71 | 0·035 | 59 | 172 | 91 | 0·055 |
| 35 | 117 | 63 | 0·055 | 60 | 145 | 75 | 0·055 |
| 36 | 121 | 70 | 0·062 | 61 | 138 | 71 | 0·062 |
| 37 | 111 | 61 | 0·071 | 62 | 145 | 76 | 0·073 |
| 38 | 118 | 62 | 0·075 | 63 | 148 | 75 | 0·071 |
| 39 | 123 | 69 | 0·043 | 64 | 105 | 57 | 0·052 |
| 40 | 111 | 55 | 0·051 | 65 | 115 | 56 | 0·043 |
| 41 | 105 | 54 | 0·053 | 66 | 145 | 75 | 0·052 |
| 42 | 108 | 53 | 0·048 | 67 | 110 | 55 | 0·047 |
| 43 | 117 | 57 | 0·053 | 68 | 115 | 56 | 0·048 |
| 44 | 118 | 54 | 0·062 | 69 | 130 | 72 | 0·056 |
| 45 | 125 | 71 | 0·058 | 70 | 125 | 69 | 0·049 |
| 46 | 118 | 56 | 0·073 | 71 | 135 | 75 | 0·052 |
| 47 | 175 | 90 | 0·075 | 72 | 179 | 90 | 0·063 |
| 48 | 165 | 89 | 0·055 | 73 | 145 | 75 | 0·048 |
| 49 | 155 | 85 | 0·053 | 74 | 110 | 56 | 0·052 |
| 50 | 147 | 73 | 0·062 | 75 | 118 | 70 | 0·048 |
| 51 | 134 | 69 | 0·052 | 76 | 170 | 90 | 0·052 |
| 52 | 128 | 71 | 0.063 | 77 | 155 | 82 | 0·045 |
| 53 | 145 | 72 | 0·053 | 78 | 165 | 81 | 0·052 |
| 54 | 114 | 56 | 0·043 | 79 | 147 | 75 | 0·062 |
| 55 | 112 | 52 | 0·055 | 80 | 144 | 73 | 0·071 |

# ON THE POSSIBLE USE OF MAGNESIUM SULPHATE AS AN ANAESTHETIC FOR EXTRACTING THE SOFT PARTS OF THE CHANK FOR BIOLOGICAL STUDIES

BY

P. S. SAMBANDAMURTHY.

Moses (1922) has recorded that the study of the anatomy of the Chank *Xancus pyrum* (Linn) is not easy because of the impossibility of getting the animal intact from the shell and that the shell is also very thick and massive that only a hammer can break it and the chances are that when the hammer breaks the shell it also injures the soft parts within. Devanesan and Chacko (1944) developed a method by which the chank shell with animal is held in position by a bench vice, a few longitudinal and circular cuts are made on the shell by a hack-saw, and a few gentle taps by a hammer exposing the animal unhurt. In the course of tagging chanks at the Marine Biological Station, Tuticorin, for studying their growth and migrations one specimen was found having several polycheate worms lodged inside holes on its shell. This chank was kept in a finger bowl of ½ litre capacity in clean sea water at 4 p.m. on 30th March 1963, an attempt was made to extract the worms by adding magnesium sulphate to saturation point as an anaesthetic. The next day at 11 a.m. only one worm was found extruded out and the others were still alive lodged inside the holes. The water in the bowl showed some milky discharge and was emitting foul smell. But the chank was found to have retracted even its operculam much into the shell. With a pair of forceps the operculam was given a slight pull and surprisingly the entire animal of the chank came out intact without any difficulty. It was preserved in 5 per cent formalin, and the tissues hardened well and thus the animal was in excellent preservation for biological studies. It is evident that the large number of holes in the shell of this particular chank have facilitated the penetration of magnesium sulphate into the interior whorls of the chank thus dislodging it intact from its shell.

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# NATURAL HISTORY OF DUGONG IN RAMESWARAM WATERS

BY

DAVIDSON THOMAS.

*Dugong*, the sluggish torpedo-shaped mammal of varying shades of grey and of dirty sand hew, known also as the Sea Cow, is a timid harmless animal grazing on the sea grass beds in sheltered bays. These are found to be inhabitants of certain restricted warmer waters in the Indo-Pacific region. In India it is found more abundantly in the Palk Bay and south coast of Gulf of Mannar of Ramanathapuram district and also in Tuticorin area. Near Cutch area also these are reported to be caught occasionally.

Known to the East Ramanathapuram fishermen for decades as *avulia* and *kadalpanni* (sea-pig), this marine mammal forms a successful shore-seine fishery in Rameswaram waters mostly between November and February. The shallow bays near Thondi, Devipattinam, Rameswaram and Kilakarai and the stretch of coral islands which are covered with sea grass are the usual grounds. The sea grass found in the area are *Cymodocea serrulata*, *Cymodocea rotundata*, *Cymodocea isaetifalia* and *Enhalus konigii*.

Dugongs are found to prefer feeding on the roots and runner stem of the sea grass rather than the leaves. Its broad and tough muzzle, with central vertical depression with hair-like growths, is used for uprooting and browsing on the sea grass roots. In some adults of about nine feet size, two tusks are noticed from either side of the upper jaw and muzzle, and these facilitates digging out the tubers and rhizomes of the sea grass. While a dugong is grazing in shallow water the tail could be seen at water surface, indicating that during feeding it supports its weight on its flippers.

Dugongs are often caught entangled in the turtle nets (gill nets) of 18-20 inches mesh size made of twisted cotton rope of about 1½ mm. thick or of twisted acacia bark fibre. Occasionally they are caught accidentally in the bottom set nets of 6 and 7 inches mesh size and also in Ray nets. The grounds where they are caught are usually covered with sea grass. Such grounds are located in the Palk Bay off Rameswaram Bay and Olaikuda and off Thondi and Sundarapandiapattinam up to 3–4 fathoms and in the shallow bays of Hare island, Appa Theevu (off Kilakarai) and near Manali islands (off Mandapam) in the Gulf of Mannar. Apart from being landed accidentally in the above nets dugongs are mainly captured in the Rameswaram Bay in shore-seine nets during the season, along with other fish. The bags and wings for these shore-seine nets are made out of sun-hemp grown in Vedaranyam (Thanjavur district).

Dugong herds are normally found in the shallow reaches of Rameswaram Bay feeding on the sea grass soon after the turbulent seas caused by the north-east monsoon and they disappear when the bay becomes little calm with the change of the winds towards east.

The refuse or faecal matter of the mammal are found along the coast of the Rameswaram Bay in globular floating mass 1–1½ inches thick, very similar to cowdung in texture. This betrays the presence of the dugong herds in the shallow bay.

From October to February, the Rameswaram Bay is usually not much disturbed by canoes and fishermen and it is in this quiet and calm atmosphere the dugong herds prefer to move closer to shore. But when disturbed they get scared and swim away.

In the Rameswaram Bay dugong herds have been observed between December–February, when these are landed. The normal size of the dugongs caught is 6–9 ft., weighing 400–600 lb. Smaller ones or baby dugongs are not very common in the catches. Most of these caught are dead when landed since in their attempt to escape they get hurt in the head region and die. Live dugong, landed are killed before cutting by a single hit on the head with a club, which is the vulnerable spot for the mammal.

The male and female proportion in the catches is about 1 : 6 or 1 : 7 ; indicating that one dugong bull has a harem of a number of cows. Many of the female members caught of size about 8 feet are often found to be in advanced stage of pregnancy. There are also adult females with the milking teats in well-developed condition. Unlike the terrestrial mammals the feeding apparatus provided for dugongs are peculiar. Only a pair of tubular structures about 2—2½ inches long and ¾ inch, thick on either side on the lower body and close to the base of the flippers, resembling a single teat of a cow are found. Well developed breast parts are not noticed. The mother dugong, gives its calf an utmost degree of care. Normally until it is strong enough to swim and defend itself, the young ones are clasped by the flippers. In calm undisturbed conditions, the mother is found to suckle its young by keeping it above water level. Usually only one calf is found along with the mother and so also one foetus has been observed in the womb of the adult female dugong caught. Some fishermen claim to have seen two foetus in the womb of a female dugong. But this is perhaps very rare. Young dugong below 3 feet in size are usually very rare in the shore-seine catches. But the young ones have been caught in the set nets and skate nets operated in deeper waters. Evidently the young ones keep themselves normally at safer distance from the shore, while the strong adults migrate and venture more shoreward and feed on the sea grass in clear water.

The flesh of dugong is considered a delicacy in some places and is much sought for. The flesh is more like pork meat and is relished by many people. In Rameswaram, the flesh of dugong is valued about 25 nP. per lb. After meeting local demand the cut slices are well rolled in salt and kept buried in mat covered pits, which drains off the water-content. After 3 days the pit is opened and the flesh dried well when it becomes hard and fibrous. This is exported to Ceylon where there is a ready market for this. The flesh is believed to be of medicinal value and said to cure all intestinal disorders. But it is believed that if taken by women in early stages of pregnancy causes abortion. The bones of the dugong are collected by poor people and sold to sugar factories and distilleries. The fatty layers are found in the abdominal walls of the dugong. These are separately collected and melted to produce oil.

This oil is consumed by people suffering from dysentery, intestinal ulcers and piles for which it is considered a remedy These are also used along with Damur for caulking boats and for application to canoes.

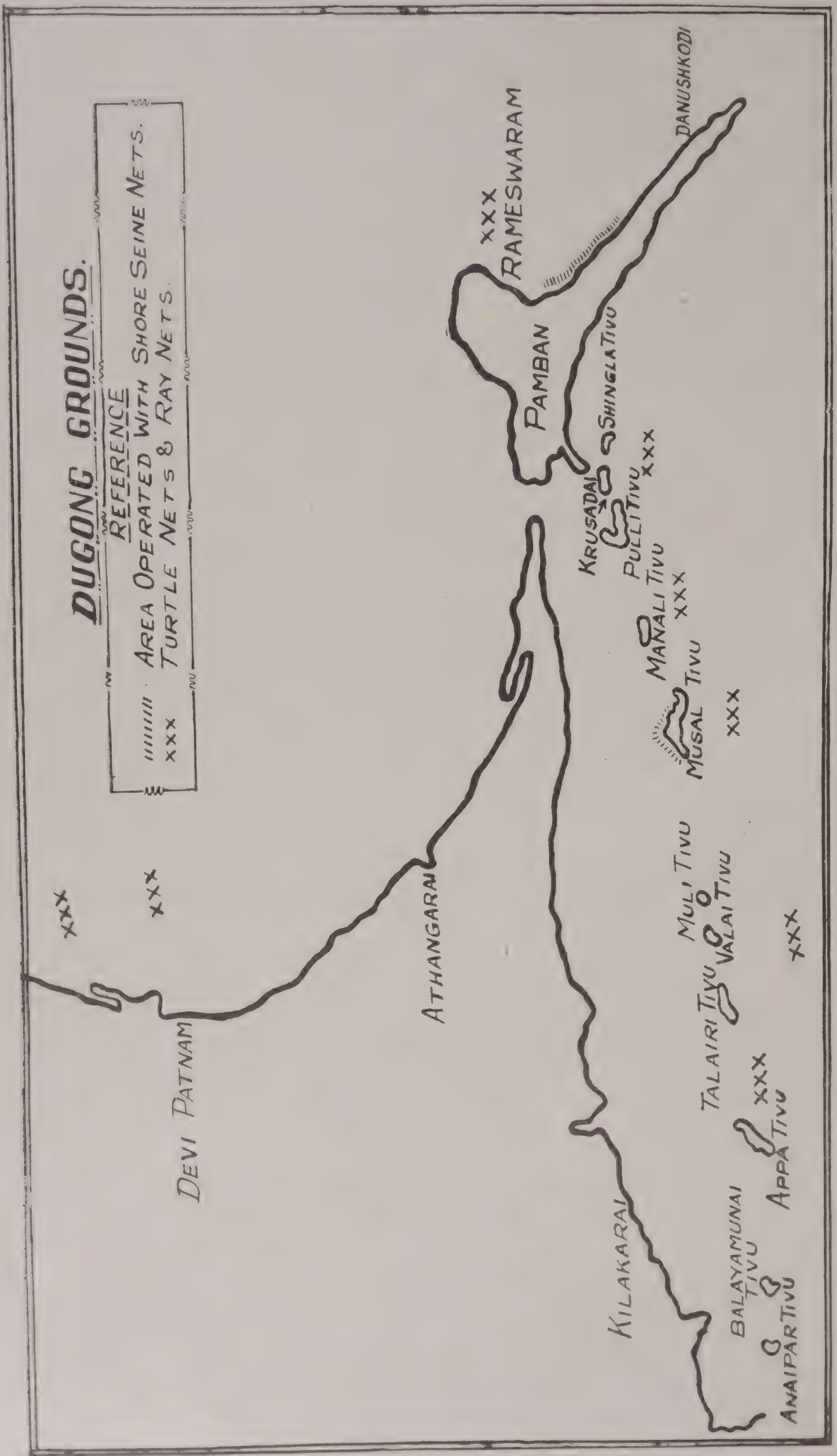
Since 1961, there had been a sudden show-down in the Ceylon market and the price for dugong flesh had come down considerably. The shore-seine fishermen are no more interested in the capture of dugong as a fishery because of the low value and difficulty in marketing and hence not much effort is made for the capture of dugongs now. The view held by some of the marine biologists that the dugongs are heading for depletion cannot be easily accepted atleast as far as our waters are concerned. More herds of dugong of 400—500 in number have been sighted in the areas than before. The congregation of dugongs in herds in the undisturbed shallow bay of Rameswaram and around the islands from November to February when the north-east monsoon is on, and then sudden disappearance after February when the easterly winds begin and the whole bay becomes more calm, indicate that the dugong herds move shore-ward when the sea is turbulent and the bottom mud layers become loose and slushy under the monsoonic conditions due to current and wave action. Stray catches of dugongs in the deeper areas in set nets and sometimes in drift nets by entangling are noticed during the other parts of the year. This proves that during calmer days these mammals are available in deeper waters.

Dugongs are considered quite hardy and could be kept alive in captivity without much care. Recently it was proved that they withstand rough handling. With a view to exhibit them in the National Agricultural Fair, Madras, January 1962, a dugong about 6 feet size was captured alive on 15th December 1961 in shore-seine net in Rameswaram Bay. This was transported in a net, without hurting its snout or head into the turtle pen bay (about a mile away) and kept tied to an anchor by its tail in the sea in one fathom depth. Nylon ropes were used for this purpose which caused some injury to the tail by abrasion. But this wound was soon found to heal up. On 26th December 1961, it was transported in a canoe to Mandapam and then loaded in a jeep trailor, giving a soft bed of sea grass of about 1 foot. Sea water was filled in the trailor, so that the water and sea grass immersed only half its body. I left Mandapam in the jeep with the dugong in the trailor at 4-30 p.m. on 26th December 1961 and reached Madras on 27th December 1961 at 6 a.m., covering the distance in the cool hours of the night. Then it was kept in the trailor till evening before it was transported to a cement tub filled with sea water. The mammal was constantly kept wet at intervals of about 30 minutes. It is clear, that, this mammal could stand such rough handling and shock taking all the bumps of the jeep trailor along the highways from Mandapam to Madras a distance of about 370 miles. Though this was found to be scared and restless during the first two days it got tamed thereafter in the tub and started moving. But care had to be taken not to hurt its snout and head.

Another dugong was captured alive on 15th January 1962 in the Rameswaram Bay. This was about 7 feet length and 310 lb. in weight. After keeping it in captivity in confined waters for 14 days, it was moved to Madras in a jeep trailor as in the previous case. At Madras it was transferred to a cement tub with sea water on 30th January 1962. Sea grass from Rameswaram was collected and sent to Madras to feed it.

It is interesting to note that for 10 days from 15th January 1962 the dugong was kept in confinement in the shallow backwaters of Karaiur, where the salinity of the water is much less. Being shallow, the temperature of water was found to be much more than the normal sea temperature during mid-day. However the dugong was found to be quite happy there in confinement. From this it is presumed that the dugong can be acclimatised to live in waters of lesser salinity. Certain members of this group in Amazon and Nile areas are said to ascend into the rivers. It would be interesting to train the dugong to live in waters of lesser salinity (brackish water) when it will become easier to keep this mammal in confinement in acquariums.

I am thankful to Sri H. K. Ghazi, I.A.S., Director of Fisheries and to Sri P. I. Chacko, Deputy Director of Fisheries, for giving me facilities and encouragement for this work.


DUGONG GROUNDS.
REFERENCE
|||||||| AREA OPERATED WITH SHORE SEINE NETS.
XXX TURTLE NETS & RAY NETS.
RAMESWARAM
DANUSHKODI
PAMBAN
SHINGLA TIVU
KRUSADAI
PULLI TIVU
MANALI TIVU
MUSAL TIVU
MULI TIVU
VALAI TIVU
TALAIRI TIVU
APPA TIVU
BALAYAMUNAI TIVU
ANAIPAR TIVU
KILAKARAI
ATHANGARAI
DEVI PATNAM

# A NOTE ON SEWAGE FISH FARM, MADURAI

BY

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Madurai, the second largest city in the Madras State with a population of about five lakhs has an ideal sewage farm covering an area of 113 acres and yielding about 100 tons of grass per acre per year. The grass first planted about 30 years ago, continues to thrive and grow well even now. The farm is maintained by the Madurai Municipality. The annual income from the farm is over one lakh of rupees .

The farm which is situated about five miles away from the town receives about 2·0 million gallons of raw sewage per day without any form of pretreatment through cast iron pipes of 24″ diameter. The farm land has a natural slope of 1 in 100 so that the sewage flows by gravity from the higher level to the lower end. It is divided into a number of smaller plots of about 2·5 acres in an area which is banked up and flooded with sewage once in eight days. The sewage water gradually percolates through the soil into the underdrainage system. The soil is composed of gravel and red loam and is therefore highly loose and porus. Underneath each plot, there are two rows of 3″ earthware effluent pipes of 12″ length and 3″ internal diameter and loose jointed at a depth of 3—4 feet below the ground level for carrying the effluent. Over the pipes is spread stone metal of 1½″ size to a height of 7″ and over this is placed 5″ thickness of small pebbles and over these there is a layer of earth of 2 feet in thickness. The effluent outlet pipes are located 33 feet apart at the lowest end of the farm and the effluent from these is collected in a common open channel and allowed to run to waste on the adjoining low land and made it unfit for any crop cultivation on account of high chloride content of the effluent.

The sewage of Madurai town is thus purified on the principles of "broad irrigation" and "intermittent down filtration". The disposal of the sewage effluent which ran into waste, in a profitable manner was thought of as an urgent necessity. Among various other possibilities it was considered that this problem can be profitably solved by the utilisation of the effluent for pisciculture as was practised in Germany and Bengal. The suitability of a sewage effluent for pisciculture is based on two tests recommended by the Royal Commission in sewage disposal 1898, i.e., the effluent should not contain more than 3.0 parts of suspended matter per 1 00,000 parts of effluent nor take up in 5 days at a temperature of 65°F more than 2·0 parts of dissolved Oxygen per 100,000 parts of effluent. Judged by these tests the effluent of Madurai sewage farm was found to the evidently suited for fish culture. The chloride content of the effluent is also higher than the influent (about 47·0 parts per 100,000) which makes it unsuitable for other purposes than fish culture.

With this object in view the Fisheries Department, suggested to the Madurai Municipality in 1949 for construction of a series of small ponds in the sewage farm site for conducting experiment on fish culture in the sewage effluent. Accordingly eight ponds of the following dimensionwere constructed to which the sewage water is let in :—

Pond No. I—Size 68′×66′×56′×32′

Pond Nos. II, III, IV—Size 55′×28′

Pond No. V—Size 75′×30′

Pond Nos. VI and VII—Size 144′×60′

Pond No. VIII—Size 800′×154′

These different ponds are used as nursery ponds, rearing ponds and stock pond. These ponds were taken over by the Fisheries Department on 13th February 1957 for a period of five years on the condition, that 50 per cent profit is payable to Madurai Municipality as compensation (*vide* G.O. Ms. No. 383, Food and Agriculture, dated 5th February 1958). The first consignment of *Tilapia* fingerlings was introduced in the Farm by Dr. Van Eleve, Director of T. C. M. Programme, United States of America, who was then touring in this State.

The fish farm is useful to rear the fry of *Rohu*, *Mrigal* and *Catla* into fingerlings and to supply *Tilapia* fingerlings for stocking inland waters of this district. The indegenous carp fingerlings are also temporarily stocked here before they are distributed to the provincialised water.

The results achieved from the Sewage Fish Farm for the past five years are furnished below :—

| *Year.* | *Quantity of fish produced.* | *Quantity of fingerlings taken out.* | *Expenditure.* | *Receipts.* | *Net profit.* |
|---|---|---|---|---|---|
| | LB. | LB. | RS. P. | RS. P. | RS. P. |
| 1957-58 .. .. .. .. | 10½ | .. | 214 59 | 3 28 | Ist year |
| 1958-59 .. .. .. .. | 520½ | 7,180 | 144 25 | 304 31 | 176 44 |
| 1959-60 .. .. .. .. | 1,221 | 14,624 | 37 22 | 646 90 | 372 19 |
| 1960-61 .. .. .. .. | 427 | 30,970 | 17 73 | 653 50 | 635 86 |
| 1961-62 .. .. .. .. | 1,106 | 1,244,272 | 10 40 | 364 25 | 353 85 |

It may therefore be seen that this Fish farm is working on a profitable scale. The Fish farm is also utilised for the induced spawning experiments on major carps. The hydrological analysis conducted during the month of April 1962 reveal the following facts :—

*Water quality.*—The water has a very high carbonate alkalinity and low bicarbonate. Chloride was high indicating pollution. Very high pH was recorded and oxygen supersaturated. Fairly moderate phosphate was noted but nitrate was not present. Dissolved solids were high, but calcium was only moderate. High sulphate was noteworthy. Very high plankton content was noted but composed of only Scenedesmus and Anabaena. Soil condition fairly good.

Of late, in maintaining the Sewage Farm, it is observed that all the ponds are over-abundant in *Tilapia*, which compete severely with the other economic species. Unless *Tilapia* is systematically eradicated from this farm the growth of other species will be much affected resulting a poor performance in the farm itself.

# CHEMICAL COMPOSITION AND FOOD VALUE OF CHANK AND PEARL OYSTERS

BY

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## INTRODUCTION

Pearl and Chank Fisheries off the Gulf of Mannar and Palk Bay of the Madras Coast are State monopolies and their fishing is conducted under the auspices of the Fisheries Department of the Government of Madras. While chank fishing is an annual and regular affair the same cannot be said of the pearl fisheries due to certain ecological and biological conditions occurring in the pearl banks. The pearl fisheries have been conducted off Tuticorin for the past six successive years and the pearl banks are rationally exploited on a scientific basis after careful assessment of the growth, population and pearl bearing nature of the oysters in the various beds.

On an average about 8 to 10 lakhs of chanks (*Xancus pyrum*) are fished annually while 1½ to 2 crores of oysters (*Margaritifera vulgaris*) have been taken out on an average over the past five years. The present paper deals with the chemical composition of the flesh and shells of chanks and pearl oysters.

## MATERIAL AND METHODS

*Chanks.*—The edible portion of the chank flesh which consists of the food of the animal is pulled out of the shell by means of sharp knife. Analysis has been conducted both on the raw flesh as well as on the boiled and dried chips of the flesh. The methods of analysis are similar to the well known standard methods of analysis of foods. The results are given in Table I.

*Pearl Oysters.*—The meat of pearl oysters are not consumed widely probably due to its unpalatable nature or due to its non-availability. However, it is known that pearl oyster meat is occasionally eaten if only they could be obtained in a fresh condition. It may be mentioned here that unlike other marine foods, the pearl oyster meat gets easily disintegrated due to its own autolytic enzymes and bacterial spoilage sets in rather quickly. For analysis, fresh oysters taken out from the sea during departmental inspections were utilised and analysed. The results of analysis are given in Table II. The amino acid composition of the oyster meat protein has been worked out by paper chromatographic techniques and the results are given in Table III.

## DISCUSSIONS

It can be seen from Table I that the food values of the fresh meat of chank compare favourably with that of the preserved form (chank chips) and are in general agreement with that of fish. The chank flesh is rich in protein and minerals, especially in protein, iron and copper. These latter two elements are effective in nutritional anaemia and they are in a form easily available for haemoglobin production. It may be of interest to point out here that the operculum is believed to cure some of the diseases of the children and this probably may be due to its high protein and mineral contents.

As can be inferred from Table II, the pearl oyster meat contains a fairly good quantity of protein and it is high in minerals and glycogen. The iodine contents of pearl oysters has not been worked out but from published literature it is learnt that pearl oyster meat contains about 200 parts per billion of iodine on fresh basis. As mentioned earlier, the oyster meat is not very popular with our people though in Japan this is considered a delicacy and after the search for pearls is over the meat is shucked, frozen, and sent or canned with suitable condiments. Gunasekara (1961) has also reported on the plain drying or salt curing of pearl oyster flesh and found the processed product to be a palatable food and a good source of protein. Table III gives the amino acid make up of the oyster meat protein and this compares favourably with the values for other foods of marine origin.

An investigation into the causes of formation of pearls in the pearl oysters was done earlier [Chari (1956)] when the meats from pearl bearing oysters and non-pearl bearing oysters were analysed chemically, with a view to find out whether any material difference exists in the course of nitrogen metabolism for stimulative secretion of the nacreous layers in the mantle. The results are given in Tables IV and V. It can be seen from both the tables that the general pattern of chemical composition of the two categories of oyster meat is almost the same excepting for the difference in the case of iron. The role played by iron in non-pearl bearing oysters is as yet not clearly understood. It may be concluded that the chemical constituents like protein, fat, ash, as well as the amino acid contents in the two categories fail to indicate the contributing factors responsible for the formation of pearls in the bivalves. However, the presence of iron as a trace element in greater quantities in non-pearl yielding oyster than pearl yielding oysters is a significant factor to be reckoned with and may require further detailed investigations.

## COMPOSITION OF THE SHELLS

The chemical composition of the two shells shows about 94 to 96 per cent calcium carbonate with 2 to 3 per cent of organic matter and less than 1 per cent of sulphates and chlorides. Though the chemical characteristics of the shells are almost identical, yet the chank shell is white and very hard unlike the oyster shell which is rather brittle and whose mother of pearl layer is irridiscent.

## CONCLUSIONS

Chank flesh is utilised by the fishermen divers as an article of food and the food values compare favourably like any other fish as could be inferred from the analytical values.

The oyster flesh is not quite so popular and is eaten only rarely. The chemical analysis shows this to be a good source of proteins, minerals and glycogen.

Chemical constituents like protein, fat, ash, phosphorus, calcium, in the flesh of the pearl yielding and non-pearl yielding oyster as well as the amino acid composition of the protein of the above two categories fail to indicate the contributing factors responsible for formation of pearls in the bivalves. However, it is significant to note that the iron content in the case of non-pearl yielding oyster meat is greater than that in the pearl yielding oyster.

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TABLE I.

*Food value of Chank flesh.*

| | | *$H_2O$ Free Basis.* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Particulars.* | *Moisture.* | *Protein.* | *Fat.* | *Total mineral matter.* | *Ca.* | *P.* | *Iron mg.* | *Copper. mg.* | *Nacl.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | PER CENT | PER CENT | PER CENT. | PER CENT. | PER CENT | PER CENT | PER CENT | PER CENT | PERCENT |
| Chank flesh (raw) .. | 67·50 | 76·43 | 2·52 | 5·66 | 0·39 | 0·29 | 8·34 | 1·32 | 1·08 |
| Chank flesh (boiled and dried-chips). | 13·04 | 80·50 | 0·53 | 5·86 | 0·27 | 0·37 | 3·62 | 1·09 | 1·47 |

TABLE II.

*Chemical composition of the pearl oysters meat.*

| | PER CENT. |
|---|---|
| Moisture .. .. .. .. .. | 77·71 |
| Protein .. .. .. .. .. | 14·42 |
| Fat .. .. .. .. .. | 0·82 |
| Total mineral matter .. .. .. | 3·36 |
| Glycogen .. .. .. .. .. | 2·69 |
| $P_2O_5$ .. .. .. .. .. | 0·23 |
| Cao .. .. .. .. .. | 0·36 |
| Iron .. .. .. .. .. | mg. 5·57 |

TABLE III.

*Amino acid composition of the pearl oyster meat calculated to 16g. of N/100g.*

| | |
|---|---|
| Leucines .. .. .. .. .. | 11·73 |
| Pyenylalanine .. .. .. .. | 2·56 |
| Valine, Methionine .. .. .. .. | 6·75 |
| Glutamic Acid and Threonine .. .. | 21·71 |
| Glycine, Serine and Aspartic Acid .. | 16·63 |
| Arginine .. .. .. .. .. | 3·92 |
| Histidine .. .. .. .. .. | 1·55 |
| Lysine .. .. .. .. .. | 6·25 |

TABLE IV.

*Chemical composition of the meat from pearl bearing and non-pearl bearing oysters.*

| *Particulars.* | *Meat from oysters with pearl.* | *Meat from oysters without pearls.* |
|---|---|---|
| (1) | (2) | (3) |
| | (PER CENT.) | |
| Original moisture .. .. | 75·30 | 74·49 |
| Nitrogen .. .. .. | 2·19 | 2·44 |
| Fat .. .. .. .. | 0·95 | 0·92 |
| Ash .. .. .. .. | 3·58 | 4·10 |
| $P_2O_5$ .. .. .. | 0·23 | 0·21 |
| CaO .. .. .. .. | 0·36 | 0·21 |
| Iron (mg.) .. .. .. | 3·90 | 25·71 |

TABLE V.

*Amino acid composition of the meat from pearl bearing and non-pearl bearing oysters, calculated to 16g. N/100g.*

| *Particulars.* | *Meat from pearl bearing oysters.* | *Meat from non-pearl bearing oysters.* |
|---|---|---|
| (1) | (2) | (3) |
| Leucines .. .. .. | 10·76 | 11·32 |
| Phenylalanine .. .. | 2·98 | 2·88 |
| Valine, Methionine .. .. | 7·45 | 6·53 |
| Tyrosine .. .. .. | 1·88 | 3·81 |
| Glutamic acid and Threonine. | 22·32 | 20·82 |
| Alanine .. .. .. | 5·03 | 3·61 |
| Glycine, Sarine and aspartic Acid. | 21·59 | 20·39 |
| Arginine .. .. .. | 4·34 | 3·51 |
| Histidine .. .. .. | 6·44 | 4·91 |
| Lysine .. .. .. | 4·85 | 6·30 |

# TOXICITY OF SOME ORGANIC AND INORGANIC SUBSTANCES TO FISH

BY

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The advances made in the application of various agricultural chemicals for crop and forest protection has posed a serious problem for fish and wild life administrators [Cottam (1960), Byrd (1960), Hoffman (1960)]. Some of these chemicals have also been used by Fishery workers for management of lakes and ponds [Fukano and Hooper. (1958), Lewis and Tarrant (1960)]. In India, the use of pesticides has not attained a stage to pose a problem for fish or wild life as it does in the U.S.A., and Japan. But great need is felt for a cheap, effective and manageable toxicant for eradication of unwanted fish from large pieces of water. With this object in view the toxicity to fish of a number of organic and inorganic chemicals has been tested.

## EXPERIMENTAL

In general, the methods prescribed by Doudoroff *et. al.* (1951) were followed with some variations. The experimental fish were taken from cement tanks with natural food, viz., heavy blooms of plankton. They were starved in holding tanks of 600 litres capacity for 24 hours prior to start of experiments. The quality of the holding water and experimental water is furnished in Table I. The toxicants were dissolved in water or other appropriate solvants and added to the test water to obtain the requisite concentration. 10·0 L water in glass aquaria jars with fishes of size 5·0 to 7·5 cms. were used generally. *Barbus mahecola* and *Rasbora daniconious* were however of sizes 8·0—10·0 cms. ; eight to ten fishes were used in each jar. Initial concentration of oxygen was kept sufficiently high to leave at least 50 per cent saturation after 24 hours. Mortality of fish during 24 hours was noted, as also the reaction of fish. The results are presented as the concentration causing 100 per cent mortality in 24 hours (Tables II and III).

## RESULTS AND DISCUSSION

Experiments with chlorinated hydrocarbons show that endrin is the most toxic of all—the 24 hour lethal dose being 0·005 to 0·012 p.p.m. as the 20 per cent emulsifiable compound (or 1/5th of this as active ingredient). *Tilapia* and *gambusia affinis* were more resistant than carps. Anderson *et. al.* (1960) found endrin to be the most toxic known chemical. Katz and Chadwick (1961) determined the toxicity of endrin to six species of fish and found that the tolerance of these fishes differed. Matida *et. al.* (1957) and Iyatomi *et. al.* (1958) have furnished data on the toxicity of endrin to fish in Japan. Next to endrin, we found chlordane and aldrin to be most toxic. Cope *et. al.* (1947) however report that 30·0 p.p.m. of chlordane was required to kill rainbow trout in 24 hours. This appears to be rather too high. Applegate (1957) indicates that 0·1 p.p.m. of chlordane was lethal to trout but not to bluegills. The results of Hatch (1957), however, closely agree with ours. Ginsburg (1945) found 0·2—1·0 p.p.m. chlordane toxic. The wide divergence in results may be due to lack of uniformity in the environmental conditions as well as in test fish. Toxaphene was found to be highly toxic next to chlordane and aldrin. Cope *et. al.* (1947) found toxaphene and chlordane equally lethal. Fukano and Hooper (1958) also recorded the high toxicity of toxaphene to fishes. However, there are conflicting opinions about the residual effect of toxaphene. Webb (1961), Handerson *et. al.* (1960) and Tarzwell (1959) found D.D.T. to be highly toxic—0·026 to 0·032 p.p.m. However Cope *et. al.* (1947), Dutt and Kundu (1960) found D.D.T. to be toxic only at higher levels as our results also indicate. Only 4·0 p.p.m. technical D.D.T. (5 per cent) was lethal to *Barbus* sp. and *Cirrhina* sp.

Phenol was found by us to be toxic to *E. maculatus* only at 30·0 p.p.m. Among others, Applegate *et. al.* (op. *cit*) found that 5.0 p.p.m. of phenol killed trout but did not affect Blue-gills. Pentachlorophenol emulsion was lethal at 10·0 p.p.m. to our minnows. It was reported to be lethal even at lower dose of 1·0 p.p.m. to trout Blue-gills, etc. [Applegate (1957)]. Paranitrophenol was more toxic than phenol but less so than pentachlorophenol. Bandt (1957) recorded that 5·0 mg./L of nitrophenols to be lethal to fish. Nicotine was lethal to some of our fishes at concentrations of 4 to 8 p.p.m. (or 20·0 to 40·0 p.p.m. as " Nicotox "). The TLm ranged from 17·0 to 25·0 p.p.m.

Chloramine-T (Sodium, P-toluenesulfonchloramide) was lethal to *Tilapia mossambica* at 28·0 p.p.m. The TLm was 25·0 p.p.m. Alpha-naphthylamine at 3·0—4·0 p.p.m. was lethal to *Barbus* sp. Saponin at 15·0 p.p.m. did not affect either *Gambusia affinis* or *Tilapia*. This is surprising since Tang (1961) reported that 100 per cent mortality was caused by 1·5 p.p.m. of Saponin to *Tilapia mossambica* under conditions similar to ours. We used pure B.D.H. saponin. Powder of the seed of *Abrus precatorius* (family *Papilionaceae*) was not at all toxic to *Tilapia mossambica* and *Barbus* sp. at concentrations up to 100 p.p.m.

Among inorganic chemicals, copper sulphate was lethal to four species of fish at 5·0 p.p.m. in 24 hours but to *Macrones vittatus* it was lethal in higher doses, viz., 10·0 p.p.m. in 72 hours or 15·0 p.p.m. in 48 hours. Toxicity was less in hard water. Kemp (1958) found 3·0 p.p.m. copper sulphate lethal to some fishes but Mackereth and Smyly (1951) found as low a conc. as 0·2 p.p.m. of Cu toxic. Tompkins (1958) used copper sulphate for capturing fishes ; from lakes. Calcium hypochlorite appears to be a cheap and efficient fish toxicant, killing *Barbus* sp. at 5·0 p.p.m. Panikker (1960) and Armstrong (1949) used it for management of ponds. We found that the lethal dose of Sodium arsenite was 50·0 to 60·0 p.p.m. well above the limits of concentration necessary to control submerged weeds. These results agree with the findings of Boschetti and Mc. Laughlin (1957) that, only 45·0 p.p.m. was toxic to fishes tested and that no mortality occurred at 15·0 p.p.m. Sodium hypochlorite was toxic only at high levels, viz. 200—400 p.p.m. to *Cyprinus carpio* (German strain) and at still higher doses only (1,500 p.p.m.) to *Tilapia mossambica*. Sodium sulphite was likewise lethal only at high conc. of 500—1,000 p.p.m. Tomiyama and Yamagawa (1950) likewise found no ill effects on fish with 268 mg/1 of Sodium sulphite. Grice (1961) also did not notice any distress of fish at 100—150 p.p.m. of sodium sulphite. Sodium cyanide was lethal for *Tilapia mossambica, murrels* and *Barbus* sp. at 0·4 p.p.m. in 24 hours.

Use of fish toxicants in fishery management is a problem engaging the attention of fishery interests. Derris root has been widely used for partial or selective killing of fish. "Killing and rearing of fish are quite compatiable procedures for obtaining the greatest fish toxicant to waters in such a way as to deliberately cause a partial or selective kill of the fish present....is the best method of fish management" [Byrd (1960)]. Toxaphene, a chlorinated comphene has come into use of late for large scale fish eradication [Tanner and Hayes (1955)].

Use of endrin in fishery management was mentioned by Prevost (1960) and Soong and Merican (1959). The latter used it successfully to eradicate fishes from mining pools. However, for the first time large scale use of endrin was made by us to eradicate *Gambusia affinis* from the 84 acre Ooty lake. This upland lake was mainly used for the culture of varieties of the German carp *Cyprinus carpio* and the crucian carp *Carassius vulgaris*. They were multiplying and growing well. This lake was the only source of fingerlings of these fishes. The inadvertant introduction of *Gambusia affinis* into the lake had the disastruous effect of preventing the breeding of these carps or of non-survival of spawn. (Sreenivasan, 1962). Initially Endrix 20 E.C. (20 percent Endrin) was applied at the rate of 0·015 p.p.m. in ponds of size 30m. × 15·5m × 1 m. Two applications were made during November 1959. A complete kill of *Gambusia* was obtained. After a lapse of a month, adult spawners of german carps (*Cyprinus carpio* var *specularis* and *C. carpio vulgaris*) were introduced. They spawned successfully, fry and fingerlings being obtained. This gave an indication that elimination of *Gambusia affinis* may facilitate the spawning of the carps and the survival of spawn. Following the successful example of Hayes and Livingstone (1955) poisoning of the shallow margin of the Ooty lake was undertaken during July 1960. *Gambusia* were invariably crowded along the surface of the shallow margins only, especially near weed beds, feeding on insect larvae. This species invariably inherits only the shallow areas and stays at the top few centimeters. Further, the lake is stratified and oxygen depletion occurs below 3·0 or 3·5 m. 4·5 litres of Endrix 20 E.C. (Shell chemicals) was sprayed along the lake margin. Roughly 90 per cent of the *Gambusia* had died as a result. Prior to the application of Endrin, with half an hour's effort two tins full of *Gambusia* were being obtained for feeding trout but after poisoning even a complete day's effort could not yield a tenth of this quantity. A known 200 number of adult *Cyprinus carpio* were also exterminated but a few were able to survive. After a month the water was tested for "residual toxicity" and found to be detoxified. In about ten weeks since spraying in September 1960, the German carps were seen playing about and had spawned successfully. Similarly in fish farms in Kodaikanal *Carassius auratus*, as well as *Cyprinus* carpio bred after years of failure when *Gambusia affinis* and *Barbus melanampyx* were exterminated, using endrin.

The cost for treating the 84·0 acres Ooty lake was just about Rs. 160·00. Since September, 1960 the Ooty lake has in fact become over-populated with the carps. There is no fear of affecting human beings or cattle. The lake is a polluted water not used by human beings for any purpose. Nor do cattle use the water. LD 50 for Endrin is reported to be 10-35 mg./kg. [Dutt and Kundu (1960)]. One has to consume 500 litres of water of 0·02 p.p.m. endrin residual to show symptoms of poisoning. Further endrin is more toxic than phosphorous insecticides to fish but less toxic than the latter for human beings [Dutt and Kundu (1960)].

In poisoning operations, it was noted that when a fine spray was directed into the water, the *Gambusia* revelled at the surface gulping the spray, whereas the carps do not come up. Though the *Gambusia* died off, the mirror carps were seen surfacing in distress only on the second day. These could be revived by transferring to non-toxic water. In a spraying programme in Chetput Fish Farm, it was observed that apart from fishes, frogs and water snakes also died. Zooplankton was eliminated. In this water, livecage experiments showed that the water remained toxic for over 45 days. This was a hard water with a hardness of 182·0 p.p.m. $CaCo^3$, a pH of 9·1 and alkalinity of 478·9 p.p.m. $(HCO^3)$.

Very judicious use of some of the modern insecticides especially chlorinated hydrocarbons could be made in fishery managements. Some of the inorganic chemicals especially calcium hypocholorite promises to be a cheap fish eradicant.

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TABLE I.

*Quality of water used for conditioning and experiments.*

| | |
|---|---|
| Temperature | 26·0—31·0°C |
| Free carbondioxide (p.p.m.) | 0·0–1·0 |
| Carbonate ($CO_3$) p.p.m. | 0·0–7·8 |
| Bicarbonate ($HCO_3$) p.p.m. | 36·6—40·0 |
| Oxygen mg/L | 5·3—8·8 |
| ph | 7·0—7·5 |
| Hardness (as $CaCO_3$) p.p.m. | 36·0 |
| Chloride (p.p.m.) | 8·0—15·0 |

### TABLE II.

### *Toxicity of Organic Chemicals to Fish.*

(Figures indicate the 24-hour Lethal Dose to kill 100 per cent of fish.)

(Those in paranthesis are the 24 TLm values in p.p.m.)

| *Species.*<br>(1) | *Endrix-20 E.C.*<br>(2) | *Dieldrix-18.*<br>(3) | *Aldrix-40 W.P.*<br>(4) | *Chlordane.*<br>(5) | *Toxaphene.*<br>(6) | *D.D.T. Technical. 5%*<br>(7) |
|---|---|---|---|---|---|---|
| 1 *Tilepia mossambica* | 0·012 (0·009) | 0·06 (0·05)—0·08 | 0·05 (0·035) | 0·07 (0·055) | 0·05 | .. |
| 2 *Barbus mehacola* | 0·01—0·008 | .. | 0·05 (0·03) | 0·05 | 0·05—0·075 | 4·0 |
| 3 *Danio* sp. | 0·009—0·006 | .. | 0·07 | 0·06 (0·045) | 0·07 | .. |
| 4 *Cirrhina* sp. | 0·01 | 0·08 (0·06) | .. | 0·06 (0·045) | .. | 4·0 |
| 5 *Labeo fimbriatus* | 0·009 | .. | .. | .. | 0·05—0·075 | 4·0 |
| 6 *Gambusia affinis* | 0·01—0·012 | .. | .. | .. | .. | .. |
| 7 *Channa* sp (murrels) | 0·006 (0·005) | 0·05 (0·04) | 0·01 | .. | .. | .. |
| 8 *Catla catla* | .. | .. | .. | 0·05 (0·04) | .. | .. |
| 9 *Cyprinus carpio* | 0·08—0·01 | .. | .. | 0·07 (0·06) | .. | .. |
| 10 *Panchax panchax* | .. | .. | .. | .. | 0·05—0·075 | .. |
| 11 *Eutroplus Maculatus* | .. | .. | .. | .. | .. | .. |

| | *Nicotox-20.*<br>(8) | *Chloramine-T.*<br>(9) | *Sandotox.*<br>(10) | *Phenol.*<br>(11) | *p. nitrophenol.*<br>(12) | *Pentachloro phenol emulsion.*<br>(13) | *a-naphthyl amine.*<br>(14) |
|---|---|---|---|---|---|---|---|
| 1 *Tilapia mossambica* | .. | 28·0 (25·0) | 3·0 | .. | 20·0 | .. | .. |
| 2 *Barbus mehacola* | 25·0 (22·0) | .. | .. | 30·0 | 15·0 | 10·0 | 3·0—4·0 |
| 3 *Danio* sp. | .. | .. | .. | .. | .. | 10·0 | .. |
| 4 *Cirrhina* sp. | 20·0 (17·0) | .. | 2·0 | .. | .. | .. | .. |
| 5 *Labeo fimbriatus* | .. | .. | .. | .. | .. | .. | .. |
| 6 *Gambusia affinis* | 30·0—40·0<br>(20·0—25·0) | .. | 6·0—7·0 | .. | .. | .. | .. |
| 7 *Channa* sp. (*murrels*) | .. | .. | .. | .. | .. | .. | |
| 8 *Catla catla* | .. | .. | .. | .. | .. | .. | |
| 9 *Cyprinus carpio* | 25·0 | .. | 1·0 | .. | .. | .. | |
| 10 *Panchax panchax* | .. | .. | .. | .. | .. | .. | |
| 11 *Eutroplus Maculatus* | 40·0 | .. | .. | 30·0 | .. | .. | |

## TABLE III.

*Toxicity of inorganic chemicals.*

| *Species.*<br>(1) | *Copper Sulphate.*<br>(2) | *Sodium hypochlorite.*<br>(3) | *Sodium aresenite. (A.R.).*<br>(4) | *Calcium hypochlorite.*<br>(5) | *Sodium Sulphate.*<br>(6) | *Sodium cyanide.*<br>(7) |
|---|---|---|---|---|---|---|
| 1 *Tilapia mossambica* | 5·0 | 400·0 | 60·0<br>(56·0) | 4·0 | 1000 | 0·4 |
| 2 *Barbus mehacola* | 5·0 | .. | 50·0 | 4·5<br>(5·0) | 500·0<br>(450·0) | 0·4 |
| 3 *Danio sp.* | 5·0 | 300·0 | .. | 4·5 | .. | .. |
| 4 *Cirrhina sp.* | .. | .. | 52·0<br>(48·0) | .. | .. | .. |
| 5 *Labeo fimbriatus* | .. | .. | 52·0<br>(48·0) | .. | .. | .. |
| 6 *Channa sp. (murrels)* | .. | .. | .. | .. | .. | 0·04 |
| 7 *Cyprinus carpio* | .. | 200·0 | 52·0<br>(50·0) | .. | .. | .. |
| 8 *Etroplus maculatus* | 5·0 | .. | .. | .. | .. | .. |

# VITAMIN 'A', COPPER AND IRON IN THE EAST COAST MARINE FISHES AVAILABLE AT TUTICORIN

BY

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The investigations on the nutritive value of important marine fishes of the West Coast of Madras for moisture, protein, fat, ash and mineral matters were already reported by Chari (1948). The nutritive value of marine fishes of Bombay province was studied by Setna *et. al.* (1944). Jeyachandran (unpublished data) has worked on the nutritive value of marine fishes found near Tuticorin. It was felt necessary to take up the estimations of Vitamin 'A' copper and iron contents, which are also vital nutrients to health, for the east coast marine fishes available in the Tuticorin area. About twenty fishes were analysed for the Vitamin 'A', copper and iron contents and the results are reported here.

## METHODS

The study was taken only on the fresh fishes got from the landing place. Only the edible portion (i.e. after the removal of scales, fins, skin, gills, guts, head and tail portion) was taken up for analysis.

The methods of sampling followed were exactly the same as given by the Association of Official Agricultural Chemists (1945) and Association of Official Vitamin Chemists (1951). For medium sized fishes about 8 fishes were taken, with moderately big fishes, three to four were taken for analysis. The edible portion was minced well with a mechanical mincer and representative samples taken for analysis.

## ESTIMATION OF VITAMIN 'A'

The representative minced sample was taken in a waring blender and added twice the amount of distilled water and blended well. Aliquots were withdrawn from the blended one and poured into an already weighed saponification flask. Reweighed. The difference in weight will give the weight of the sample for analysis. As described in the A.O.V.C. (1951) conducted saponification with 3 cc. of 1 : 1 potassium hydroxide and 30 cc. alcohol. The unsaponifiable matter was extracted with ether in successive quantities from the separating funnel. The last traces of moisture from the ether was removed by filtration through anhydrous sodium sulphate and then the last traces of the ether was evaporated in an inert medium. The unsaponifiable matter left behind was taken with cyclohexane and Vitamin 'A' estimated using Unicam spectrophotometer.

## ESTIMATION OF COPPER AND IRON

The method for the estimation of copper was followed as given by Callen and Handerson (1929). Copper was estimated in the ash extract using sodium diethyldithio carbamate in the spectrophotometer. The iron content was estimated in the ash extract using xx dipyridyl in the spectrophotometer as per Andrews and Fett (1941).

Table I gives the vernacular (Tamil), common English name and scientific name of the fishes, and the estimations of vitamin 'A', copper and iron contents.

## DISCUSSIONS

The presence of vitamin 'A', copper and iron is also an index of the nutritive value of the fish. In addition to protein, fat, calcium and phosphorus, these can also be considered to be the vital nutrients. There are wide variations in the contents of vitamin 'A', copper and iron contents in the fishes taken up for study.

Tarr (1954) has estimated the vitamin 'A' for some of the fishes like salmon, cod, haddock, mackerel, sword fish, etc. Almost all fishes contain less than 400 I.U. per 100 gm. of flesh in the wet basis. Hirao *et. al.* (1959) have examined 157 species of fish for vitamin 'A' in fish flesh. Eighty-five per cent of the species contained less than 200 I.U./100 gm. of fish muscle. In the fishes analysed in this laboratory, vitamin 'A' ranges from 27 I.U. to 325 I.U./100 gm. of the muscle.

Riddel (1936) and Choudhury and Basu (1939) have estimated copper contents in the fish. Riddell (loc. *cit.*) found the copper content to vary from 0·03 to 0·12 mg./g. of ash. Saha (1941) estimated copper content of some fresh water species of fish and found that they contain less than 0·2 mg./100 gm. in wet basis. Table I shows that copper ranges from 0·02 mg./ per cent to 2·24 mg. per cent and iron ranges from 0·7 mg. to 9·0 mg. per cent in wet basis.

The fishes that contain more than 200 I.U./100 gm. of vitamin 'A' in the muscle have also been reported by Jeyachandran to be high in protein and fat content also indicating that they are highly nutritious.

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TABLE I.

*Amounts of Vitamin 'A', copper and iron in the marine fishes.*

| Local name (Tamil). | Common name (English). | Scientific name. | Weight of average fish in Kg. | Average length in cm. | Edible portion percent. | Wet basis. | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Copper mg./100 gm. | Iron mg./100 gm. | Vitamin 'A' I.U./100 gm. |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 Ullam | Shad | *Hilsa ilisha* | 0·11 | 18·0 | 62·5 | 0·32 | 0·88 | 84·37 |
| 2 Kathalai | Jew fish | *Sciaena sp.* | 0·17 | 8·5 | 66·6 | 0·72 | 4·26 | 36·24 |
| 3 Soorai | Tuna | *Euthinnus sp.* | 0·70 | 38·3 | 68·0 | 0·14 | 1·42 | 129·80 |
| 4 Kuddippu | Big jawed jumper | *Lactarius sp.* | 0·10 | 23·5 | 80·0 | 0·15 | 1·90 | 255·90 |
| 5 Parai | Horse mackerels | *Carnax sp.* | 0·20 | 26·0 | 68·8 | 0·09 | 6·64 | 164·60 |
| 6 Vengadi | Torpedo fish | *Megalaspis cordyla* | 0·28 | 24·0 | 63·6 | 0·15 | 2·90 | 298·00 |
| 7 Chenguli | Red soldier fish | *Holocentrus rubrum* | 0·20 | 20·0 | 75·0 | 0·07 | 2·50 | 284·30 |
| 8 Panna | Silver banded jew fish | *Otolithus argenteus* | 0·60 | 32·0 | 66·7 | 0·04 | 3·17 | 325·80 |
| 9 Sura | Shark | *Carcharius sp.* | 1·00 | 41·00 | 82·5 | 0·10 | 2·87 | 30·46 |
| 10 Soodai | Sardines | *Sardinella gibbosa* | 0·03 | 14·0 | 71·0 | 0·03 | 3·65 | 160·00 |
| 11 Vellai Vaval | White promfret | *Stromateus argenteus* | 0·25 | 24·0 | 80·0 | 0·10 | 1·87 | 222.00 |
| 12 Keluthi | Cat-fish | *Arius jella* | 0·25 | 26·0 | 66·7 | 1·19 | 9·02 | 98·70 |
| 13 Katta | Leather skin | *Chorinemus sp.* | 0·33 | 28·3 | 60·0 | 2·10 | 1·08 | 202·10 |
| 14 Seela | Seer fish | *Cybium sp.* | 0·60 | 42·3 | 75·0 | 1·80 | 2·00 | 107·30 |
| 15 Valai | Wolf herring | *Chirocentrus dorab* | 0·90 | 52·0 | 77·7 | 0·28 | 1·10 | 70·90 |
| 16 Cheppili | Golden Snapper | *Lutianus sp.* | 0·50 | 26·0 | 70·0 | 2·24 | 0·70 | 46·00 |
| 17 Thamban | Vermilion Coral cod | *Serranus miniatus* | 1·00 | 37·0 | 68·0 | 0·98 | 1·30 | 45·50 |
| 18 Kanankeluthi | Mackerel | *Rastrelliger sp.* | 0·30 | 26·0 | 66·7 | 0·62 | 1·15 | 112·30 |
| 19 Salai | Sardines | *Sardinella fimbriata* | 0·03 | 12·0 | 70·0 | 0·34 | 2·64 | 53·40 |
| 20 Keerimeensalai | Sardines | *Sardinella sirm* | 0·04 | 18·0 | 66·7 | 1·07 | 0·70 | 63·51 |
| **21** Pambu Mural | Round tail alligator | *Tylosurus strongylurus* | 0·017 | 21·0 | 70·6 | 0·40 | 0·31 | 27·54 |

# TEMPERATURE ACCLIMATION AND OXYGEN CONSUMPTION IN FRESH WATER FISH

BY

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Temperature dependence of respiration in fishes is well understood [Krogh (1916)]. Oxygen consumption in poikilotherms increases with increasing temperature up to a particular limit. [Zeuthen (1947)] however points out that a cold-blooded animal when transferred to a lower temperature has its metabolic rate reduced immediately but after being kept for some days at this lower temperature, a higher rate of metabolism ensues. Wohlschlag (1960) has confirmed this "Cold adaptation" in poikilotherms. Scholander *et al.* (1953) found that oxygen consumption by tropical fishes is about five times the rate for Arctic species at 0°0 C and 30 to 40 times the hypothetical rate of tropical forms at 0° C—This statement has a bearing on reduction of metabolism of tropical fish and hence a few experiments were made to study the respiratory rate of thermally acclimated fish.

Fish (of sizes 6—12 cms.) were conditioned in small containers, one set acclimated to a higher tropical temperature of 28 to 30° C and another to a lower temperature of 18 to 20°C (with the test species used, viz., *Barbus sp.* and *Cirrhina reba*, still lower temperature could not be tried since these fishes died at 15°C. Even fry of *Tilapia mossambica* died of cold shock at 15° C). Oxygen consumption was studied for exactly half an hour. The following combinations were used:—

Oxygen consumption by 'warm' fishes (those acclimated to 28 to 30°C) at 'warm temperature' and at 'cold temperature'; Oxygen consumption by cold fishes (those acclimated to 18–20°C) at 'cold temperature' and at 'Warm temperature'. The results are tabulated below: —

| *Experiment number.* | *Acclimation temperature.* 30°C. *oxygen consumption in mg.* | | *Acclimation temperature.* 20°C. *oxygen consumption in mg.* | |
|---|---|---|---|---|
| —— | 30°C. | 20°C. | 30C. | 20°C. |
| 1. *Cirrhina reba* .. | 2·48 | 0·32 | 2·0 | 0·72 |
| 2. *Cirrhina reba* .. | 1·68 | 0·48 | 2·16 | 1·12 |
| 3. *Cyprinus carpio* | .. | .. | 0·23 | 0·19 |
| 4. *Barbus sp.* .. | 1·3 | 0·20 | 3·7 | 1·8 |

*Note.*—In the case of Barbus sp. the 'warm' temperature was 28°C and 'cold' temperature 18°C.

The results indicate that in the case of fish acclimated to a higher temperature, oxygen consumption falls very significantly when transferred to a lower temperature. What is striking is that this lowered rate of respiration is even far below that of the respiration of cold acclimated fish at the 'cold' temperature. Wells (1935) and Sumner and Wells (1942) also obtained similar results—They found that fishes acclimated to 30°C showed lower rate of oxygen consumption at 20°C than the ones kept acclimated at 20°C or the ones transferred from 10° to 20°C.

The effect of size on the relationship between thermal adoptation and respiration would be an interesting study.

My thanks are due to Mr. J. Natarajan, Refrigeration Engineer, Mettur Dam for facilities provided.

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# EXPERIMENTS ON THE USE OF COCONUT OIL IN CANNING PRAWNS (PENAEUS INDICUS)

BY

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## INTRODUCTION

In India prawns contribute to a major fishery of economic importance especially on the West Coast. At present the bulk of the catches is sun-dried for export to Burma and South-East Asian countries. Of late, Indian prawns preserved by canning have established a good market in the United States and Western Europe, thus earning valuable foreign exchange for our development programmes. During 1960, export of prawns from India yielded foreign exchange worth Rupees thirty million.

There are vast potentialities of developing internal markets for prawns provided improved processing methods are employed, so that products appealing to the Indian consumers are made available at reasonable prices. Experiments conducted at the Fisheries Technological Sub-Station, Cape Comorin, have proved that a gravy made of chillies, and coconut oil yielded a very good medium for canning of prawns. The results of these investigations are presented in this paper.

## MATERIAL AND METHODS

Marine prawns (*Penaeus indicus*) caught in boat seines from the inshore waters off Cape Comorin during July 1961 were used for these experiments. The prawns were processed immediately after landing when most of them were alive. These were washed in sea water and immersed in boiling 5 per cent brine for five minutes. While still hot the heads were severed, de-veined and the shells removed. The remaining flesh was packed in thirty cans, of size 301×206, 100 grams in each can. To each can was added 20 ml. of a gravy prepared as follows. 100 grams of dried chillies were finely powdered and heated with 500 ml. of fresh coconut oil for fifteen minutes. To this were added 50 grams of powdered common salt, 50 grams of cane sugar and another half a litre of coconut oil and heating continued for another 15 minutes with continuous stirring. The mixture was strained through cotton cloth and the resultant filtrate was used as gravy. After the addition of the gravy the cans were exhausted by placing them in boiling water immersed up to 1 cm. below the tops of the cans for ten minutes. The cans were then closed and sealed immediatey using a Metal Box domestic can sealer. The sealed cans were divided into three batches of ten each and sterilised in steam at 120°C (steam pressure=15 pounds per square inch) for 45, 60 and 75 minutes respectively followed by cooling in running cold water. The cans were stored at room temperature for a period of up to fourteen months and the contents periodically examined. Total volatile basic nitrogen and trimethylamine nitrogen were determined by the method of Conway (1947) using the press-juice prepared by grinding the prawns with solid trichloracetic acid. pH of the medium was determined using B.D.H. indicator paper strips. The organoleptic assessment of the products was carried out as suggested by Farber and Ferro (1956).

## RESULTS AND CONCLUSION

The results of the periodic analysis are summarised in Table I. It was found that the products retained excellent keeping quality throughout the period of storage of fourteen months. There was no significant difference in the TMAN and TVBN values for the three sets of samples in spite of difference in the duration of sterilisation. Further it was found that sterilisation at 120°C for a period of 45 minutes was quite sufficient to ensure good keeping qualities for the product. The usual objection to the use of coconut oil as a medium for canning of fish is its relatively high solidification point of 22°C. But in a tropical country like India, there are very few regions outside the hill stations where atmospheric temperature falls below 22°C, that too only for a short period during the winter. The solidification point of coconut oil can be reduced to 10°C if so desired by incorporating 10 per cent of rice bran oil [Harsono Hardjohutomo (1958)]. The addition of rice bran oil to coconut oil will have a further advantage because of the presence of alphatocopherol a powerful antioxidant in rice bran oil. This will help inhibit the progress of spoilage by oxidative processes. The only reference so far about the use of coconut oil as a medium for canning fish is by Soejarwidodo (1958) who found it quite satisfactory for the species. *Clupea fimbriata* and *Caranx sexfasciatus* in Indonesia. With the availability of sufficient supplies of coconut oil at reasonable cost, the method of canning of prawns described is quite practicable and worth a trial by the Indian fish canning industry.

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## TABLE I.

*Result of storage studies on canned prawns.*

| *Storage period.* | *Batch.* | *A.* | *B.* | *C.* | *Remarks.* |
|---|---|---|---|---|---|
| Fifteen days .. | pH of medium .. .. | 6·1 | 6·1 | 6·1 | Batch-A. Sterilised for 45 minutes. |
| | TVBN (mgm/cent) .. | 0·64 | 0·65 | 0·64 | |
| | TMAN (mgm/cent) .. | 0·062 | 0·071 | 0·071 | |
| | Org. Score (Max-10) .. | 10·0 | 10·0 | 10·0 | |
| Thirty days .. | pH of medium .. .. | 6·1 | 6·1 | 6·1 | Batch-B. Sterilised for 60 minutes. |
| | TVBN .. .. .. | 0·64 | 0·65 | 0·64 | |
| | TMAN .. .. .. | 0·062 | 0·071 | 0·071 | |
| | Org. Score .. .. .. | 10·0 | 10·0 | 10·0 | |
| Forty-five days .. | pH of medium .. .. | 6·2 | 6·2 | 6·2 | Batch-C. Sterilised for 75 minutes. |
| | TVBN .. .. .. | 0·64 | 0·65 | 0·64 | |
| | TMAN .. .. .. | 0·070 | 0·071 | 0·071 | |
| | Org. Score .. .. .. | 10·0 | 10·0 | 10·0 | |
| Three months .. | pH of medium .. .. | 6·2 | 6·2 | 6·2 | |
| | TVBN .. .. .. | 0·64 | 0·65 | 0·64 | |
| | TMAN .. .. .. | 0·070 | 0·070 | 0·071 | |
| | Org. Score .. .. .. | 10·0 | 10·0 | 10·0 | |
| Four months .. | pH of medium .. .. | 6·2 | 6·2 | 6·2 | |
| | TVBN .. .. .. | 0·65 | 0·66 | 0·66 | |
| | TMAN .. .. .. | 0·070 | 0·071 | 0·071 | |
| | Org. Score .. .. .. | 10·0 | 10·0 | 10·0 | |
| Five months .. | pH of medium .. .. | 6·2 | 6·2 | 6·2 | |
| | TVBN .. .. .. | 0·66 | 0·65 | 0·65 | |
| | TMAN .. .. .. | 0·071 | 0·070 | 0·072 | |
| | Org. Score .. .. | 10·0 | 10·0 | 10·0 | |
| Six months.. .. | pH of medium .. .. | 6·2 | 6·2 | 6·2 | |
| | TVBN .. .. .. | 0·66 | 0·66 | 0·66 | |
| | TMAN .. .. .. | 0·071 | 0·072 | 0·072 | |
| | Org. Score .. .. .. | 10·7 | 10·0 | 10·0 | |
| Fourteen months .. | pH of medium .. .. | 6·2 | 6·2 | 6·2 | |
| | TVBN .. .. .. | 0·66 | 0·66 | 0·66 | |
| | TMAN .. .. .. | 0·071 | 0·072 | 0·072 | |
| | Org. Score .. .. .. | 10·0 | 10·0 | 10·0 | |

# A STUDY ON THE LOSS OF WEIGHT OF COMMON SALT DUE TO DRYAGE DURING STORAGE IN FISH-CURING YARDS

BY

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## INTRODUCTION

The results of experiments conducted during the years 1960 and 1961 in assessing the loss of weight of common salt stored in fish-curing yard godowns in Madras State on prolonged storage in gunny bags are presented in this paper.

## MATERIAL AND METHODS

Ordinary and alkathene lined gunny bags of two maunds (75 Kg.) capacity and common salt with a minimum of 96 per cent Nacl generally used for fish curing were used for these investigations. Ten ordinary gunnies and ten alkathene lined gunnies were packed with 75 Kgs. each of crushed common-salt and stacked in vertical rows of five bags each placed over wooden sleepers on the cemented floor in the salt godowns of the fish-curing yards. The experiments were carried out at Cape Comorin and Adiramapattinam. The initial gross weights of the individual bags were recorded on the day of packing. Subsequent weighments were made once every fortnight viz., on the first and fifteenth of every month to cover a total storage period of one year. The weights were recorded using standardised Avery platform weighing machines.

## RESULTS AND CONCLUSIONS

The data recorded at Cape Comorin are given in Tables I and II respectively for salt stored in ordinary gunnies and alkathene lined gunnies. The net loss or gain in weight of the experimental bags are given in Table III. Corresponding data for Adiramapattinam are given in Tables IV, V and VI.

An analysis of the data collected at Cape Comorin shows that the average loss in weight of salt kept in alkathene lined gunnies due to dryage for a period of one year was 1·09 per cent or 0·82 kg. per bag. The loss of weight recorded during the same period in the salt stored in ordinary gunny bags was 3·8 per cent or 2·85 kg./bag. For the experiments conducted at Adiramapattinam the corresponding figures were 6·46 per cent (4·84 kg./bag) in the alkathene lined bag and 13·03 per cent (9·77 kg./bag) in the ordinary gunny bag. These figures have been arrived at assuming that the gain or loss, if any, in the weights of the material of the bags was negligible during the period of experiments. It was also observed that the bags kept at the bottom of the stacks recorded a slight increase in weight in the case of alkathene lined gunnies stored at Cape Comorin. In the corresponding ordinary gunnies the net loss of weight was the least among the latter, as was to be expected because of the proximity of the bags to the floor of the godown. No such observations were made at Adiramapattinam.

The data recorded clearly showed that with the use of alkathene lined gunnies for the storage of salt in fish-curing yards the wastage of salt due to dryage can be reduced considerably. But economically there is not much gain in using alkathene lined bags instead of ordinary gunny bags as the cost of one alkathene lined gunny bag is Rs. 2·20 as against the cost of Rs. 1·25 only for one ordinary bag and as the value of the contents, namely common salt is not much.

## ACKNOWLEDGMENTS

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Table I.

*Showing the weights of ordinary gunnies with salt in the Cape Comorin Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

| *Gunny number.* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gunny weight. | 1·81 | 2·15 | 2·38 | 1·7 | 1·7 | 1·8 | 1·8 | 1·9 | 2·72 | 2·38 |
| *Date of record.* | | | | | | | | | | |
| 1st October 1960 | 76·46 | 76·80 | 77·05 | 76·35 | 76·35 | 76·46 | 76·46 | 76·57 | 77·36 | 77·03 |
| 15th October 1960 | 77·0 | 78·13 | 75·98 | 75·75 | 75·3 | 76·09 | 75·86 | 75·86 | 75·56 | 76·09 |
| 1st November 1960 | 75·98 | 76·2 | 76·43 | 75·75 | 77·0 | 76·2 | 75·86 | 76·32 | 76·54 | 75·9 |
| 15th November 1960 | 75·75 | 77·86 | 76·2 | 75·63 | 78·01 | 76·09 | 75·75 | 76·2 | 76·43 | 78·81 |
| 1st December 1960 | 75·18 | 75·30 | 75·52 | 75·18 | 75·56 | 75·18 | 75·3 | 75·75 | 76·09 | 78·58 |
| 15th December 1960 | 74·61 | 74·84 | 75·07 | 74·96 | 75·68 | 75·3 | 75·3 | 75·75 | 76·2 | 78·47 |
| 1st January 1961 | 74·05 | 74·39 | 74·4 | 74·39 | 76·2 | 74·39 | 74·4 | 74·96 | 75·3 | 77·0 |
| 15th January 1961 | 74·16 | 74·4 | 74·73 | 74·4 | 76·32 | 74·16 | 74·62 | 74·95 | 75·3 | 76·89 |
| 1st February 1961 | 73·6 | 74·04 | 74·39 | 74·16 | 76·2 | 73·6 | 74·28 | 74·62 | 75·07 | 76·66 |

TABLE I—*cont.*

*Showing the weights of ordinary gunnies with salt in the Cape Comorin Fish-curing Yard*—cont.

(WEIGHTS IN KILOGRAMS.)

| *Gunny number.* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gunny weight. | 1·81 | 2·15 | 2·38 | 1·7 | 1·7 | 1·8 | 1·8 | 1·9 | 2·72 | 2·38 |
| *Date of record.* | | | | | | | | | | |
| 15th January 1961 .. .. | 73·48 | 73·94 | 74·28 | 74·28 | 75·98 | 73·48 | 74·04 | 74·39 | 74·73 | 76·43 |
| 1st February 1961 .. .. | 73·6 | 74·04 | 74·39 | 74·16 | 76·2 | 73·6 | 74·28 | 74·62 | 75·07 | 76·66 |
| 15th February 1961 .. .. | 73·48 | 73·94 | 74·28 | 74·28 | 75·98 | 73·48 | 74·04 | 74·39 | 74·73 | 76·43 |
| 1st March 1961 .. .. | 73·03 | 73·6 | 73·82 | 73·6 | 75·52 | 72·92 | 73·6 | 74·39 | 74·39 | 76·2 |
| 1st April 1961 .. .. | 72·69 | 73·48 | 73·7 | 73·48 | 75·3 | 73·03 | 73·6 | 76·16 | 74·04 | 75·86 |
| 15th April 1961 .. .. | 73·14 | 73·6 | 73·82 | 73·6 | 75·52 | 72·92 | 73·48 | 73·94 | 73·94 | 76·2 |
| 1st May 1961 .. .. | 73·03 | 73·6 | 73·8 | 73·37 | 75·52 | 72·92 | 73·03 | 73·94 | 73·94 | 76·2 |
| 15th May 1961 .. .. | 72·92 | 73·48 | 73·6 | 73·14 | 74·41 | 72·9 | 72·92 | 73·82 | 73·82 | 76·2 |
| 1st June 1961 .. .. | 73·48 | 73·94 | 74·27 | 74·39 | 76·2 | 73·48 | 73·71 | 74·16 | 74·16 | 76·66 |
| 15th June 1961 .. .. | 73·26 | 73·94 | 74·38 | 74·38 | 76·43 | 73·71 | 73·94 | 74·62 | 74·71 | 75·56 |
| 1st July 1961 .. .. | 73·48 | 74·28 | 74·38 | 73·48 | 76·67 | 73·6 | 74·05 | 74·62 | 74·28 | 77·34 |
| 15th July 1961 .. .. | 73·48 | 74·16 | 74·39 | 73·48 | 76·43 | 73·48 | 73·94 | 74·62 | 74·16 | 77·11 |
| 1st August 1961 .. .. | 73·14 | 73·48 | 73·94 | 73·03 | 75·75 | 73·48 | 73·94 | 74·62 | 74·05 | 77·0 |
| 15th August 1961 .. .. | 73·03 | 73·26 | 73·71 | 73·26 | 75·75 | 73·39 | 73·94 | 74·39 | 74·16 | 76·66 |
| 1st September 1961 .. .. | 72·92 | 73·14 | 73·48 | 73·26 | 75·52 | 73·39 | 73·82 | 74·16 | 73·93 | 76·2 |
| 15th September 1961 .. | 72·69 | 72·92 | 73·26 | 73·03 | 75·07 | 73·03 | 73·59 | 74·16 | 74·16 | 76·43 |

TABLE II.

*Showing the weights of alkathene lined gunnies with salt in the Cape Comorin Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

| *Gunny number :* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gunny weight : | 1·13 | 1·25 | 1·25 | 1·25 | 1·13 | 1·25 | 1·25 | 1·25 | 1·25 | 1·25 |
| *Date of record.* | | | | | | | | | | |
| 1st October 1960 .. .. | 75·78 | 75·89 | 75·89 | 75·89 | 75·78 | 75·89 | 75·89 | 75·89 | 75·89 | 75·89 |
| 15th October 1960 .. .. | 75·52 | 75·86 | 75·98 | 76·09 | 75·86 | 75·86 | 75·75 | 75·86 | 75·98 | 75·86 |
| 1st November 1960 .. .. | 75·64 | 75·86 | 75·86 | 75·18 | 75·86 | 76·09 | 75·98 | 75·86 | 75·98 | 75·98 |
| 15th November 1960 .. | 75·64 | 75·86 | 75·98 | 76·09 | 75·92 | 75·98 | 75·86 | 75·75 | 76·2 | 75·98 |
| 1st December 1960 .. .. | 75·64 | 75·86 | 75·75 | 75·98 | 76·09 | 75·75 | 75·86 | 75·64 | 75·86 | 76·2 |
| 15th December 1960 .. | 75·64 | 75·86 | 75·75 | 75·98 | 76·09 | 75·75 | 75·86 | 75·64 | 75·86 | 75·2 |
| 1st January 1961 .. .. | 75·64 | 75·75 | 75·64 | 75·98 | 76·09 | 75·75 | 75·75 | 75·64 | 75·86 | 75·2 |
| 15th January 1961 .. .. | 75·3 | 75·75 | 75·86 | 76·2 | 76·32 | 75·75 | 75·86 | 75·75 | 75·98 | 76·43 |
| 1st February 1961 .. .. | 74·96 | 75.52 | 75·64 | 75·86 | 75·86 | 75·52 | 75·75 | 75·52 | 75·75 | 76·09 |
| 15th February 1961 .. .. | 75·07 | 75·41 | 75·41 | 75·86 | 75·98 | 75·3 | 75·98 | 75·3 | 75·64 | 76·09 |
| 1st March 1961 .. .. | 74·84 | 75·41 | 75·52 | 75·64 | 75·86 | 75·18 | 75·41 | 75·18 | 75·41 | 75·86 |
| 15th March 1961 .. .. | 74·96 | 75·41 | 75·52 | 76·2 | 75·86 | 75·18 | 75·52 | 75·52 | 75·52 | 76·43 |
| 1st April 1961 .. .. | 74·84 | 75·52 | 75·86 | 76·43 | 76·43 | 75·3 | 75·52 | 75·52 | 75·52 | 75·98 |
| 15th April 1961 .. .. | 74·73 | 75·3 | 75·41 | 75·75 | 76·42 | 74·73 | 75·52 | 75·3 | 75·52 | 76·66 |
| 1st May 1961 .. .. | 74·62 | 75·07 | 75·07 | 75·64 | 76·09 | 74·39 | 75·3 | 75·3 | 75·41 | 76·2 |
| 15th May 1961 .. .. | 74·62 | 75·3 | 75·18 | 75·52 | 76·09 | 74·39 | 75·07 | 75·18 | 75·41 | 76·43 |
| 1st June 1961 .. .. | 75·07 | 75·41 | 75·41 | 75·75 | 76·88 | 75·52 | 75·3 | 75·18 | 75·3 | 76·55 |
| 15th June 1961 .. .. | 74·84 | 75·3 | 75·52 | 75·64 | 77·11 | 74·39 | 75·41 | 75·3 | 75·3 | 76·66 |
| 1st July 1961 .. .. | 75·07 | 75·52 | 75·52 | 75·75 | 77·11 | 74·39 | 75·18 | 75·41 | 75·41 | 77·0 |
| 15th July 1961 .. .. | 75·3 | 75·75 | 75·75 | 75·98 | 77·22 | 74·62 | 75·52 | 75·41 | 75·41 | 76·88 |
| 1st August 1961 .. .. | 75·3 | 75·75 | 75·41 | 75·75 | 76·88 | 74·50 | 75·41 | 75·31 | 75·41 | 76·66 |
| 15th August 1961 .. .. | 75·07 | 75·52 | 75·41 | 75·64 | 76·88 | 74·50 | 75·07 | 75·07 | 75·3 | 76·20 |
| 1st September 1961 .. .. | 75·07 | 75·3 | 75·07 | 75·3 | 76·32 | 74·28 | 74·96 | 75·96 | 75·07 | 76·43 |
| 15th September 1961 .. | 74·4 | 74·96 | 74·84 | 75·07 | 76·09 | 74·82 | 74·62 | 74·73 | 74·73 | 76·20 |

TABLE III.

*Showing the loss/gain in weight of the experimental salt bags for a storage period of one year in Cape Comorin Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

| *Serial number.* | *Alkathene lined gunnies.* | | | *Serial number.* | *Ordinary gunnies.* | | | *Remarks.* |
|---|---|---|---|---|---|---|---|---|
| | *Initial weight.* | *Final weight.* | *Difference.* | | *Initial weight.* | *Final weight.* | *Difference.* | |
| 1 | 75·78 | 74·40 | — 1·38 | 1 | 76·46 | 72·69 | — 3·77 | Bags with serial numbers 5 and 10 were kept at the bottom of the stacks. |
| 2 | 75·89 | 74·36 | — 0·93 | 2 | 76·80 | 72·92 | — 3·88 | |
| 3 | 75·89 | 74·84 | — 1·05 | 3 | 77·05 | 73·26 | — 3·79 | |
| 4 | 75·89 | 75·07 | — 0·82 | 4 | 76·35 | 73·03 | — 3·32 | |
| 5 | 75·78 | 76·09 | + 0·31 | 5 | 76·35 | 75·07 | — 1·28 | |
| 6 | 75·89 | 74·82 | — 1·07 | 6 | 76·46 | 73·03 | — 3·43 | |
| 7 | 75·89 | 74·62 | — 1·27 | 7 | 76·46 | 73·59 | — 2·87 | |
| 8 | 75·89 | 74·73 | — 1·16 | 8 | 76·57 | 74·16 | — 2·41 | |
| 9 | 75·89 | 74·73 | — 1·16 | 9 | 77·36 | 74·16 | — 3·20 | |
| 10 | 75·89 | 76·20 | + 0·31 | 10 | 77·03 | 76·43 | — 0·60 | |
| Total loss of weight .. | | | 8·22 | | | | 28·55 | |
| Average loss of weight. .. | | | ·32 | | | | 2·85 | |
| Average per cent of loss. .. | | | 1·9 | | | | 3·80 | |

TABLE IV.

*Showing weights* of ordinary gunnies with salt in the Adiramapattinam Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

| *Gunny number.* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Gunny weight 0·93.* | | | | | | | | | |
| *Date of record.* | | | | | | | | | | |
| 1st July 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 15th July 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 1st August 1960 .. .. | 73·39 | 73·39 | 75·0 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 | 73·39 | 75·0 |
| 15th August 1960 .. .. | 73·39 | 73·39 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 |
| 1st September 1960 .. .. | 73·39 | 73·39 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 | 73·86 |
| 15th September 1960 .. | 72·92 | 72·92 | 73·39 | 73·39 | 73·39 | 73·39 | 73·39 | 73·39 | 72·46 | 72·92 |
| 1st October 1960 .. .. | 72·46 | 72·46 | 72·46 | 72·46 | 72·46 | 72·92 | 72·92 | 72·46 | 72·46 | 72·46 |
| 15th October 1960 .. .. | 72·46 | 71·99 | 72·46 | 71·99 | 71·99 | 72·46 | 72·46 | 71·99 | 71·53 | 71·99 |
| 1st November 1960 .. .. | 71·99 | 71·99 | 71·99 | 71·53 | 71·53 | 71·99 | 71·99 | 71·53 | 71·53 | 71·53 |
| 15th November 1960 .. | 71·99 | 71·53 | 71·53 | 71·53 | 71·53 | 71·99 | 71·53 | 71·53 | 71·53 | 71·53 |
| 1st December 1960 .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 15th December 1960.. .. | 71·06 | 71·53 | 71·53 | 71·06 | 71·53 | 71·99 | 71·53 | 71·53 | 71·53 | 70·13 |
| 1st January 1961 .. .. | 70·13 | 70·59 | 70·59 | 70·13 | 70·59 | 71·06 | 71·06 | 71·59 | 71·59 | 69·19 |
| 15th January 1961 .. .. | 69·66 | 69·66 | 69·66 | 69·66 | 70·59 | 70·59 | 70·59 | 70·13 | 70·13 | 68·73 |
| 1st February 1961 .. .. | 69·19 | 69·19 | 69·19 | 69·19 | 69·66 | 70·13 | 70·59 | 70·13 | 70·13 | 68·73 |
| 15th February 1961 .. .. | 68·26 | 68·26 | 68·73 | 68·26 | 68·73 | 69·19 | 69·19 | 69·66 | 69·19 | 67·79 |
| 1st March 1961 .. .. | 67·79 | 68·26 | 68·73 | 68·26 | 69·19 | 69·19 | 69·19 | 69·19 | 69·19 | 67·79 |
| 15th March 1961 .. .. | 67·79 | 67·79 | 67·79 | 69·79 | 67·79 | 68·73 | 69·66 | 68·73 | 68·73 | 67·33 |
| 1st April 1961 .. .. | 66·86 | 67·33 | 67·33 | 67·33 | 67·33 | 68·26 | 68·73 | 67·79 | 67·79 | 66·86 |
| 15th April 1961 .. .. | 66·86 | 67·33 | 67·33 | 66·86 | 66·86 | 68·26 | 68·73 | 67·79 | 67·79 | 66·86 |
| 1st May 1961 .. .. | 66·86 | 67·33 | 67·33 | 66·86 | 66·39 | 68·26 | 67·79 | 67·33 | 67·33 | 65·93 |
| 15th May 1961 .. .. | 65·93 | 66·86 | 66·86 | 66·39 | 66·39 | 68·26 | 67·79 | 67·33 | 67·33 | 65·93 |
| 1st June 1961 .. .. | 65·36 | 66·39 | 66·39 | 64·99 | 65·93 | 66·86 | 66·86 | 66·39 | 65·93 | 65·46 |
| 15th June 1961 .. .. | 64·99 | 65·53 | 64·99 | 64·53 | 65·46 | 66·39 | 65·93 | 65·46 | 64·99 | 64·99 |
| 1st July 1961 .. .. | 64·53 | 65·46 | 64·99 | 64·53 | 64·99 | 65·93 | 65·93 | 65·93 | 65·46 | 64·53 |

* Weights exclusive of the gunny.

### Table V.

*Showing the weights* of alkathene lined gunnies with salt in the Adiramapattinam Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

| Gunny number. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gunny weight 0·93 kg. | | | | | | | | | |
| *Date of record.* | | | | | | | | | | |
| 1st July 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 15th July 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 1st August 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 15th August 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 1st September 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 15th September 1960 .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 1st October 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 15th October 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 |
| 1st November 1960 .. .. | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 73·86 |
| 15th November 1960 .. | 75·0 | 75·0 | 73·86 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 75·0 | 73·86 |
| 1st December 1960 .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 15th December 1960.. .. | 75·0 | 75·0 | 72·92 | 75·0 | 73·86 | 75·0 | 75·0 | 75·0 | 73·86 | 72·92 |
| 1st January 1961 .. .. | 73·86 | 75·0 | 72·92 | 75·0 | 72·92 | 75·0 | 75·0 | 75·0 | 73·39 | 72·46 |
| 15th January 1961 .. .. | 73·39 | 73·86 | 72·46 | 75·0 | 72·46 | 75·0 | 73·39 | 73·86 | 72·92 | 71·8 |
| 1st February 1961 .. .. | 73·39 | 73·86 | 72·46 | 75·0 | 72·46 | 75·0 | 73·39 | 73·86 | 72·92 | 71·8 |
| 15th February 1961 .. .. | 72·46 | 72·92 | 71·99 | 75·0 | 71·53 | 75·0 | 72·46 | 73·39 | 71·99 | 71·53 |
| 1st March 1961 .. .. | 72·46 | 72·92 | 71·99 | 75·0 | 71·53 | 75·0 | 72·46 | 73·39 | 71·99 | 71·53 |
| 15th March 1961 .. .. | 72·46 | 72·92 | 71·99 | 75·0 | 71·53 | 75·0 | 72·46 | 72·92 | 71·53 | 71·06 |
| 1st April 1961 .. .. | 71·53 | 71·99 | 71·06 | 75·0 | 71·06 | 73·86 | 71·99 | 72·46 | 71·06 | 71·06 |
| 15th April 1961 .. .. | 71·53 | 71·99 | 71·06 | 71·86 | 71·06 | 73·86 | 71·99 | 72·46 | 71·06 | 71·06 |
| 1st May 1961 .. .. | 71·53 | 71·99 | 71·06 | 73·86 | 71·06 | 73·86 | 71·99 | 71·99 | 71·06 | 71·06 |
| 15th May 1961 .. .. | 71·06 | 71·53 | 70·59 | 73·39 | 70·13 | 73·39 | 71·53 | 71·99 | 70·59 | 70·59 |
| 1st June 1961 .. .. | 70·59 | 71·06 | 70·13 | 72·46 | 69·19 | 72·92 | 71·06 | 71·52 | 70·63 | 70·13 |
| 15th June 1961 .. .. | 70·13 | 70·59 | 69·66 | 71·53 | 69·19 | 72·46 | 71·06 | 71·06 | 69·66 | 69·66 |
| 1st July 1961 .. .. | 69·56 | 70·13 | 69·19 | 71·06 | 69·19 | 72·46 | 71·06 | 70·54 | 69·19 | 69·19 |

* Weights exclusive of the gunny.

### Table VI.

*Showing the loss/gain in weight of the experimental salt bags for a storage period of one year in the Adiramapattinam Fish-curing Yard.*

(WEIGHTS IN KILOGRAMS.)

| Serial number. | Alkathene lined gunnies. | | | Serial number. | Ordinary gunnies. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | Initial weight. | Final weight. | Difference. | | Initial weight. | Final weight. | Difference. | |
| 1 | 75·0 | 69·56 | — 5·44 | 1 | 75·0 | 64·53 | — 10·47 | |
| 2 | 75·0 | 70·13 | — 4·87 | 2 | 75·0 | 65·46 | — 9·54 | |
| 3 | 75·0 | 69·19 | — 5·81 | 3 | 75·0 | 64·99 | — 10·01 | |
| 4 | 75·0 | 71·06 | — 3·94 | 4 | 75·0 | 64·53 | — 10·47 | |
| 5 | 75·0 | 69·19 | — 5·81 | 5 | 75·0 | 64·99 | — 10·01 | |
| 6 | 75·0 | 72·46 | — 2·54 | 6 | 75·0 | 65·93 | — 9·07 | |
| 7 | 75·0 | 71·06 | — 3·94 | 7 | 75·0 | 65·93 | — 9·07 | |
| 8 | 75·0 | 70·54 | — 4·46 | 8 | 75·0 | 65·93 | — 9·07 | |
| 9 | 75·0 | 69·19 | — 5·81 | 9 | 75·0 | 65·46 | — 9·54 | |
| 10 | 75·0 | 69·19 | — 5·81 | 10 | 75·0 | 64·53 | — 10·47 | |
| Total loss of weight .. | | | 48·43 | | | | 97·72 | |
| Average loss of weight .. | | | 4·84 | | | | 9·77 | |
| Average per cent of loss .. | | | 6·46 | | | | 13·03 | |

# A NOTE ON THE UNSUITABILITY OF THE PHILIPPINE METHOD OF BRINE-CURING OF FISH FOR INDIAN CONDITIONS

BY

JOSEPH, K. C. AND SRINIVASAN, R.

## INTRODUCTION

Salt-curing continues to be the most widely employed method of fish preservation in India, the chief methods being dry-salting, pit-curing and brine-curing. Even though the basic principles involved in the various methods are sound, the finished products are often unsatisfactory and of poor storage quality, partly because of the insanitary conditions under which the processing operations are conducted in our coastal villages and partly because of lack of standard techniques of preparation for the various products. The need for fixing quality standards for the various salt-cured, and dried fish products to promote their trade in the export and internal markets has been felt for a long time and work has recently been taken up by the Indian Standards Institution in this direction in colloboration with the various Fisheries Technological Laboratories all over the country.

In the meanwhile some investigations, were taken up at the Fisheries Technological Station, Tuticorin, for improving the current methods of fish-curing in Madras State. One of the methods tried was to adopt the Philippine method of brine-curing for Indian conditions. The results of this study are presented in this paper.

## MATERIAL AND METHODS

Sulit and Laron (1958) reported the excellent appearance, taste and keeping qualities of dried split-salted fishery products known as '*daeng*' in the Philippines prepared by curing the scaled, split and eviscerated fish in concentrated brine for not less than 12 hours, soaking the cured fish in fresh water for 90—120 minutes and drying the product in the sun for at least 16 hours. The present studies were conducted following the processing method described above with the seaperch, *Lethrinus sp.* (local name: Vilameen). The specimens used were, purchased fresh from the local hooks and line catches and immediately scaled, split, eviscerated and cleaned well by washing. These were kept in saturated brine for 18 hours. The brine was prepared from Tuticorin solar salt. The samples were then removed from the brine and divided into three lots. One was soaked in plenty of fresh water for 30 minutes and the second similarly for 120 minutes. The rest was dried in the sun without soaking in fresh water so as to serve as the control sample. After the soaking in the fresh water the other samples also were dried in the sun for three consecutive days, the total time of exposure to the sun being 18 hours each. The products were kept in storage in deal wood cases lined inside with paper and examined periodically for their keeping qualities. Moisture, sodium chloride total volatile basic nitrogen and trimethyl amine nitrogen of the products were assessed periodically for a storage period of three months. In addition the samples were assessed organoleptically for their appearance, texture, odour, flavour, surface moisture and fungal attack. Moisture and Nacl were estimated as per A.O.A.C. methods, (1955). TVBN and TMAN were estimated from the fish muscle extract prepared by grinding with 20 per cent trichlor-acetic acid according to the microdiffusion technique of Conway (1957).

## RESULTS

The analytical data gathered from the periodic analyses are given in Table I.

The moisture content was only 27·86 per cent in the control sample as against 32·11 per cent in the sample soaked in fresh water for 30 minutes and 33·80 per cent in the sample soaked in fresh water for 120 minutes. The moisture content was thus found to progressively increase with the duration of soaking in fresh water. However, in all the cases, the moisture content was found to be below the range of 35 to 40 per cent normally found in salt cured fish. On storage up to 120 days, there was only very slight reduction in the moisture content ranging from 0·15 per cent to 0·71 per cent in all the samples.

The sodium chloride which was 23·17 per cent in the control sample, was decreased to 22·06 per cent by soaking for 30 minutes in fresh water and to 19·28 percent by soaking for 120 minutes. There was no appreciable change in the Nacl content in all the samples on storage.

The TVBN was the highest at 350 mg./100 gm. in the control sample and progressively decreased with the increase in time of soaking in fresh water. In sample BI, it was 308·5 mg./100 gm. and in sample B II it was 295·5 mg. 100 gm. In all the cases, it increased gradually on storage, the increase being progressively faster with the increase in the time of soaking. On storage for 120 days the increase was 61·00 mg./100 gm. in the control sample, as against increase of 78·00 mg./100 gm. in sample BI and increase of 98·5 mg./100 gm. in sample B II.

TMAN was 110 mg./100 gm. in the control sample and 112·5 mg./100 gm. in sample B I, but it was comparatively low at 98·0 mg./ 100 gm. in the sample B II. It increased gradually in all the cases on storage.

In appearence the control sample was whitish and attractive but with blisters till about 60 days when it began to assume a light brown colour. In samples B I and B II, though there were no blisters, the products were light brown in colour even to start with and the colour gradually deepened on storage.

In texture, the control sample was firm initially and became soft after 30 days; whereas the samples B I and B II were soft even to start with and became very soft on storage for 120 days and 30 days respectively. The control sample was found to be better in flavour and odour than the other two samples initially and at all stages of storage all the samples developed marked pungent and ammoniacall odour after 60 days' storage and had fungal attack after 120 days, the attack being more marked in the case of the samples soaked in fresh water.

## DISCUSSION

Sulit and Laron (loc. cit) found over-salting as a common defect in Philippines in the preparation of all dried split-salted fishery products which were consequently susceptible to the attack of molds due to the hygroscopic nature of the solar salt impurities, especially magnesium chloride (Lafant, 1952). As magnesium chloride is more soluble than sodium chloride, they attempted to eliminate the magnesium chloride and salt impurities together with some salt by soaking the cured fish after brining, in fresh water upto 120 minutes before drying in the sun for 16 hours. They found that the cured fish soaked in fresh water from 90 to 120 minutes were ideal in physical appearance, taste and storage qualities. In our experiments also, soaking in fresh water dissolved out the magnesium chloride and salt impurities and improved appearance of the product which was light brown in colour and was free from " blisters " characteristic of the cured fish prepared with solar salt. The T.V.B. (N) and T.M.A. (N) which are the normal indices of soilage were also found to be comparatively lower in the products prepared by soaking in fresh water than the ordinary brine-cured fish. As against these apparent advantages, the product prepared by soaking in fresh water was however found to be much inferior to the ordinary brine cured fish in flavour, texture and storage qualities. The product was soft even to start with and the fresh cured flavour was lost within the first four week and the product developed pungent odour after thirty days The higher moisture content and low sodium chloride are probably responsible for earlier deterioration and fungal attack of the product soaked in water than the ordinary brine-cured fish. It is therefore concluded that the Philippine method of soaking in water after brine-curing of fish is not helpful in improving the quality of the cured fish but on the other hand it is found to lower the texture, flavour and storage qualities of the product and so the method is not found suitable under Indian conditions.

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## TABLE I.

*Showing the results of periodical analysis of brine-cured fish (Lethrinus sp.).*

| *Storage period in days.* | *Sample.* | *A.* | *B I.* | *B .* |
|---|---|---|---|---|
| Initial | Moisture (per cent) | 27.86 | 32·11 | 33·80 |
| | Nacl (per cent) | 24·17 | 22·06 | 19·28 |
| | TVBN (mgm/cent) | 350·0 | 308·5 | 295·5 |
| | TMAN (mgm/cent) | 110·0 | 112·5 | 98·0 |
| | Appearance | Whitish with 'blisters.' | Light brown, no blister. | Light brown, no blister |
| | Texture | Medium hard. | Soft. | Soft. |
| | Flavour | Good. | Fair. | Fair. |
| | Odour | Fresh cured. | Fresh cured. | Fresh cured. |
| | Surface moisture | Nil. | Nil. | Nil. |
| | Fungal attack | Nil. | Nil. | Nil. |
| 30 | Moisture (per cent) | 27·82 | 31·90 | 33·21 |
| | Nacl (per cent) | 24·17 | 22·03 | 19·07 |
| | TVBN (mgm/cent) | 377·5 | 311·0 | 312·5 |
| | TMAN (mgm/cent) | 122·5 | 116·0 | 99·5 |
| | Appearance | Whitish. | Light brown. | Light brown. |
| | Texture | Soft. | Soft. | Very soft. |
| | Flavour | Fair. | Poor. | Poor. |
| | Odour | Slightly pungent. | Slightly pungent. | Slightly pungent. |
| | Surface moistrue | Nil. | Nil. | Nil. |
| | Fungal attack | Nil. | Nil. | Nil. |
| 60 | Moisture (per cent) | 28·18 | 31·52 | 33·24 |
| | Nacl (per cent) | 24·25 | 20·98 | 18·94 |
| | TVBN (mgm/cent) | 400·5 | 374·5 | 373·0 |
| | TMAN (mgm/cent) | 125·5 | 116·5 | 115·5 |
| | Appearance | Light brown. | Brown. | Brown. |
| | Texture | Soft. | Soft. | Very soft. |
| | Flavour | Poor. | Poor. | Poor. |
| | Odour | Pungent. | Pungent. | Pungent. |
| | Surface moisture | Nil. | Nil. | Nil. |
| | Fungal attack | Nil. | Nil. | Nil. |
| 90 | Moisture (per cent) | 27·42 | 31·96 | 33·09 |
| | Nacl (per cent) | 23·85 | 22·14 | 18·83 |
| | TVBN (mgm/cent) | 411·0 | 386·5 | 394·0 |
| | TMAN (mgm/cent) | 157·0 | 136·0 | 130·0 |
| | Appearance | Brownish | Deep brown. | Dark brown. |
| | Texture | Soft. | Soft. | Very soft. |
| | Flavour | Poor. | Poor. | Very poor (off). |
| | Odour | Ammoniacal. | Ammoniacal. | Ammoniacal. |
| | Surface moisture | Nil. | Nil. | Nil. |
| | Fungal attack | Nil. | Nil. | Nil. |

*Remarks*—

A—Control sample.
B I—Soaked in fresh water for 30 minutes before drying.
B II—Soaked in fresh water for 120 minutes before drying.

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1. Manuscripts of papers offered for publications in the Madras Journal of Fisheries should be typed on one side on foolscap paper and double-spaced throughout. Pages should be consecutively numbered. Two copies of the manuscript should be submitted.

2. The title of the paper should be brief and to the point and wholly in capitals. This is followed by the author (s) name (s) with the initials preceding the surname.

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In the text the reference should be cited thus—Ralph and Hurley (1952), with the author's surname followed by the year of publication in parenthesis.

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# A STUDY OF THE STRUCTURAL COMPONENTS OF THE ADHESIVE DISC OF ECHENEIS (ARTEDI) AND THEIR FUNCTIONS

BY

B. BONNELL AND MRS. K. JEYACHANDRAN.

## PART I.

### Introduction

Interest in the adhesive apparatus of Echeneis fish has been evinced since Aristotle's time, i.e., B.C. 384–322 owing to a report that it was capable of holding back fast moving ships of the time. Gunther (1860) traced the history of the fish. In the nineteenth century after the advent of the theory of evolution Blainville (1822) Kner (1861) Baudelot (1867) Beck (1879) Niemiec (1885) and Storms (1888) studied the apparatus with a view to ascertaining whether it was the modified middle fin of the Teleost. Houy (1909) contributed a valuable paper with histological information as well. The present paper however has become a necessity owing to the discovery that " a curious round ossification ", of Storms (1888) in the posterior end of the disc proper has now been shown to form part of a possible pumping system by Bonnell (1961, 1962, 1964) in " Nature ". Moreover the body is found in different positions in Xray photographs of the living fish taken by the kindness of the Smithsonian Institute, Washington. In following the clue further a very detailed and complete account of all the systems involved has inevitably to be made and published in parts. The last part would contain the functions of the adhesive disc and the discussion of the position that has been taken by the author.

### Material and Methods

In addition to the three very small specimens of Echeneis ranging between 105 mm. and 111 mm. in length supplied by the courtesy of the Smithsonian Institute, Washington, fourteen specimens of Echeneis (remora) ranging between 95 mm. and 137 mm. and one specimen of Osteochir 172 mm. sent from St. Andrews Fisheries Station, New Brunswick, Canada, two specimens of Echeneis 342 mm. and 356 mm. long from the Australian museum Perth, one 148 mm. long from Portonovo by the courtesy of Professor Seshiah, some specimens from the Director of Fisheries Madras, and thirty or more specimens secured locally were available for study. The methods adopted for study were dissections and preparation of the skeleton of large specimens, staining of the entire sucker with Alizarine red and rendering it transparent in glycerine as well as section cutting and staining of smaller forms.

The problem to be finally solved would be whether the mechanical movements vary according as the fish is swimming about or is attached to a place and how the change from one condition to another is harmoniously brought about. Incidentally it would throw light upon whether the apparatus has any other function or functions in addition to that of attachment.

### Externals of the Sucker

The sucker is an oval structure attached to the body in various ways. It has a flap all round freely movable while swimming which is narrow in front broader at the sides and broadest behind. Very fine ciliary sensory organs are present on its dorsal side and there are some special sensory organs arranged not far from the margin each of which appears to be a raised ring from within which a fleshy structure seems to peep out. These probably communicate with the deeper layer while the others with the superficial one.

The central part of the sucker consists of a disc with a small triangular shield at the front end in which there is a depression occupied by a curved finger shaped body the *Tactilodact.* The front edge of this shield is not attached to the skull below. From the posterior apex of the shield a median muscular partition runs backwards connecting the front shield with a much larger posterior shield at the hind end. In this partition smaller finger like bodies are embedded one for each segment which are the *subtactilodacts.*

Every segment has a pair of lamellae which are capable of being raised and which have teeth arranged in three rows along their hind margin. From the cavities in which the lamellae settle two fine grooves lead out which may be called *glyphs.* One of the two glyphs leads outwards and slightly forwards. The other is close to the median muscular partition and leads from the cavity to the next one following it.

This sort of arrangement suggests that the sea water which fills the cavities of the lamellae is driven backwards when the lamellae close. There are 24 pairs of lamellae normally. Out of them 15 are situated on the skull itself and cannot move when the sucker is attached to a place. Since the bones of the skull are immovable all the 15 lamellae are also incapable of movement once attachment has taken place.

The remaining nine pairs of lamellae are not situated on the head but on the five vertebrae following the head. Since each vertebra is capable of moving on the other from side to side, when the portion situated on them is attached although vertical movement is impossible, side to side movement can take place within certain limits. This seems to be the reason why when the fish is attached to a place the fishermen are able to release it by pushing it sideways in the hind region.

Behind the lamellar region the posterior shield is situated. It can move from side to side with the nine pairs of lamellae just anterior to it. The hind part of the shield is not attached to the neck region on its under side because the marginal flap is tucked under it. The ectodermal covering of the entire dorsal side of the adhesive disc is continued below the marginal flaps and continued over the body of the fish. The dorsal side is closely studded with pigment spots which below the flap are fewer in number and widely separated.

### Skeleton of the Sucker

The accompanying (Fig. 1), shows all the skeletal parts separated and mounted in the correct order on black paper except the delicate median tactilodacts. The left row represents the dorsal views of the basal plates. The first plate and the last two or three are specially modified. In the normal condition the basal plates overlap to a certain extent. The middle row represents the interneural bones arranged with their hind regions shifted to a side. The right row are of the Lamellar bars arranged in pairs. The lower inner ends are attached to each other by a ligament normally.

### Pyriboss

Starting from the hind end of the disc the first piece is the curious round ossification referred to above. The dorsal view of this body (Fig. 2) which I have called the *Pyriboss* brings out the following points. It has a narrow spout at the front which posteriorly is continued into a groove which in turn opens into the interior of the rounded body by a very large opening. There are two pairs of articulating surfaces at the sides disposed at different angles. In the normal postition the basiarch in front is in contact with the first pair of articulating surfaces. The second pair are free. Innumerable very small protruding tubes closely packed in rows are visible. They seem to be arranged longitudinally in curved rows and have larger outer mouths. These tubes definitely open into the interior of the body which is hollow although the openings are clearer in some cases than in others. The upper surface is flat. As the lower surface extends beyond the upper a dorsal view shows the ventral portion projecting out at the sides. There are some clear small round openings for the blood vessels or nerves to enter.

In the ventral view there is an opening in the anterior region below the very large opening mentioned in the dorsal view. It is very much smaller in size and placed in the anterior part of a shallow depression. In the lateral region small openings for blood vessels and nerves are present. The very small tubes found on the upper side are present in the ventral view as well but in smaller numbers. They are also longitudinally disposed but less closely packed. The dorsal part is mostly hidden when viewed from below and visible only to a very small extent in the hind region.

The side view shows that the dorsal surface is flat while the ventral is rounded. This is but what one would expect because the dorsal surface would have to come in contact with the surface to which it attaches itself but not so with the ventral. Further details of the structure of the Pyriboss are revealed in longitudinal and cross sections, taken with the aid of a microtome.

**Figure 3 shows** that the walls at the sides are strongly built and that they contain honey comb like cells within which many stained objects are visible. Dr. R.J. Terry, head of the Bilology Department of the University of Texas, South U.S.A., who had the opportunity to examine the slides expressed himself thus, " This structure may be characteristic of the sucker fish only. It is unlike any other vertebrate observed. It seems to be a bed of blood and lymph vessels closely associated yet separated by partitions or septa. Capillaries, arterioles, lymph vessels and vennules are unmistakably present in each of these separate units."

Figure 4 is a longitudinal section of the Pyriboss. In it the front and the hind walls are thick but the upper and lower walls are very thin and probably yielding. In which case the contents of the receptacle can be altered in volume. Gaps in the hind wall show that the pulvinus is in continuity with the interior. Changes in the volume can assist drawing in of fluids in one direction and sending them out on the other.

### Basiarch

The next skeletal piece in front is the Basiarch (Fig. 5) which is median in position. The dorsal view shows a process pointing forwards. The arch itself has slight expansions along its margins intended for providing rests for the arch in front. After the two sides of the arch have diverged for a certain distance they curve inwards slightly so that the arch takes on the appearance of a semicircle now trying to close on itself. This curve seems to be scooped out on its dorsal surface which means that it forms a place of rest for some hard part or other. Since the Pyriboss is known to fit into the space formed by the arch it must be resting on this site.

In the ventral view just behind the median prominence pointing forwards the arch is scooped out. It would form a surface below which the front end of the Pyriboss takes shelter when it is fixed in·the gap formed by the arch. It would also prevent it from getting through the gap. Houy in his figure has made a mistake in representing the Pyriboss as possessing the large opening in the hind region. In fact however it is in front and the two projections he represents as projecting forwards really project backwards and limit the posterior pair of lateral grooves. The mistake can easily arise if the bones of the posterior shield are disengaged by boiling and then fitted together. Since the Pyriboss have two pairs of lateral grooves it can be fitted into the Basiarch either by the first pair of grooves or the second. But if the bones are separated as the tissues undergo putrification the fact that it is the first pair of grooves that fit into the Basiarch cannot be missed. Moreover only then can the set of four bones functions as a pump.

The Basiarch when looked at from the side shows that the inturned posterior border of the arch bends down and ends in a fat leaf-like plate the front tip of which projects into the space enclosed by the arch. The leaf-like area fits into the lateral grooves of the Pyriboss. The outer margin of the hind region of the arch contains tiers of large openings with smaller openings within them which in their turn have still smaller openings.

### Basilid

The next piece (Fig. 6) is situated in the front middle line and has escaped attention till now and therefore has not been recorded. I have called it the *basilid.* If it had been noticed this apparently insignificant extremely small piece would have been recognized as a valve. It is a flat plate varying in shape to a considerable extent. In the dorsal view, there is a margin along the outer and lower borders with a very few scattered tubes in them. There is a distinct cleft in the front border intended to accommodate the anterior prominence of the basiarch which in the normal position passes below the lid.

In the ventral view there are two distinct bulges with a channel between them. There are also scattered round openings leading into the cavity formed by the bulges. Some very fine tubes with larger outer openings somewhat similar to those found on the pyriboss are found here also in the marginal region. The lamellar bars on their under sides possess bulges. It is therefore reasonable to consider the basilid as the lamellar bars of that segment which have fused together along the midregion with a groove in between. If the basilid is considered as belonging to the arch in front of it called the *basiplatt*, to distinguish it from the other basal plates of the disc, then the pyriboss must be considered as the modified lamellar bars of the basiarch which have fused along their inner edges leaving a groove in between with a spout in front. If a pair of lamellar bars bend backwards and fuse together and the bars exend only up to the bulges which now have greatly increased in size we shall get a body similar to the pyriboss.

Houy considers the pyriboss as the modified basal plate or stirrup-shaped piece and not of the lamellar bars fused between them because the basilid was not found at all at the time. Infact the pyriboss can be derived either from the basal plate or the lamellar bars. Since the bulges on the basilid have made us decide that it is derived from the lamellar bars, the pyriboss must be derived also from them. The advantage is that only two segments are involved in modification and not three or four if the Basilid is also taken to represent a segment.

### Basiplatt

The fourth skeletal piece (Fig. 7) which together with the other three occupies the posterior shield of the disc is the basiplatt spelt with a double t to distinguish it from the other basal plates. It has a median front prominence just as the basiarch has, projecting from a central connecting piece from which bridges diverge backwards at an angle and broaden out into larger plates. Slight rims along the front margin and the inner margin of the broad plates afford resting places for the skeletal piece in front and the basiarch behind. A fine curved arch is formed along the lower margin of the middle region which when the basiarch is fitted in position encloses a space over which the basilid rests.

The ventral view shows that there is a small channel or groove formed on the median front prominence which must be a continuation of the channel in the basilid. Along the outer margins of the basiplatt openings that lead into tubes that converge are arranged in tiers.

### Tactilodacts

All along the middle line there are thin curved rod-like processes the first of which is that of the tactilodact mentioned already as occupying a pit in the front shield. It differs from the others that follow,in that it has flattened bifurcations which touch a prominence on a cup-like skeletal piece below. Muscles are attached on the underside of the bifurcations and to the median bones below the basal plate. By their contraction the structure is raised and the lowering is brought about by the contraction of the connective tissue joining it to the basal plate.

The subtactilodacts have also bifurcations which end in knobs meeting the lamellar bars on their inner lower margins (Fig. 8). They have on either side an elongated tooth even larger than the teeth of the third row of teeth belonging to the lamellar bars. Moreover, they curve inwards and then outwards forming as it were protections to the subtactilodact.

The number of subtactilodacts is less than the number of lamellae because the last lamella has no subtactilodact. If however we consider the main tactilodact as belonging to the first lamella then the last subtactilodact now existing will belong to the last lamella. And this is a perfectly reasonable position to take, if the function of a tactilodact is to raise and lower a lamella. According to this interpretation the subtactilodact found in a lamella is not responsible for raising the lamella on which it is placed but of the next one following. The last lamella therefore does not need a tactilodact as there is no erectile structure behind.

Since these peculiar finger-like bodies have not been mentioned till now all that has been said about them cover new ground.

### Lamellobasal

Coming now to the other bones that have to be described, the first is the *lamellobasal.* Just as we considered the posterior shield of the disc as being formed of two segments the anterior shield must also be considered as being formed of two fused segments, but one complicate bone. Its dorsal view (Fig. 9) shows that its front end is semicircular in outline and in the very middle of it there is a prominence projecting backwards to which the tactilodact is attached. Behind this are a pair of arches which are separated by a gap. Looking down through this gap we see two pillars supporting the arches converging and joined together below. There is a cup-shaped hollow and the floor of the cup is joined to the front region by a curved connection. Posteriorly there is an elongated spine which is broadened at its front end side ways and in each of the expansions an oval cavity with a callous area in its centre can be noticed. The ventral flattened plates with openings in them are so broad that they with the portions in front can account for two segments.

In a typical segment omitting the very small tactilodacts, the following bones are present : A pair of lamellar bars (Zahn platten of G. Beck; Lames pectines of Niemiec) the basal plate (fussplatt of G. Beck ; ostrabeculaire of Niemiec) and interneural spine. The lamellobasa described above is formed by the fusion of two such sets and is the most complicated of all the bones.

In the ventral view (Fig. 10) all around the semicircular front end exceedingly small tubes are closely arranged and point inwards. There is a thickened knob situated at the front end of the middle line which seems to be itself riddled with holes. From this thickened knob a vertical ridge runs along the spine of the internueral bone. The spine itself is broad close to its front end and on it we noticed the callous regions of the dorsal side.

**Lamellar bars**

Behind the Lamellobasal, the lamellar bars are arranged in pairs the number normally is 24. The first pair are shortened and directed outwards and forwards. From this bar a large straight hook or peg projects forwards and inwards. The inner edge of the bar is flattened and ends in two small prominences. The innermost prominence is attached to its compliment on the other side by a ligament. The other has a callous area in its ventral aspect. In the ventral view a large entrance leads into the substance of the bone. The hook itself has several holes which lead into tubes that run across it.

The next pair is more or less like the first with these differences. The hook is at a different angle. On the ventral side the hook has a bulge which is hollow and a bridge connects it with the callous area in the inner edge of the bar. There are two openings one in front and another behind the bridge which are in communication with each other through spaces below the bridge and also with the interior of the bulge. As we proceed further backwards the length of the lamellar bars progressively increase till about the 20th pair and then decrease once again. The angle and curvature of the hook vary from one pair to another. It is possible to insert as many as five bristles from the lower cavity to the upper one, to the hook and the bulge below it. Microtome sections made through the lamellar bar longitudinally and transversely to the axis of the disc show that the bar is hollow and that there are some channels which seem to wind through the bar.

While the front margin of the bar is convex (Figure 11) the hind margin is concave and is grooved in which three rows of teeth are accomodated. The wall separating the teeth from the lamellar bar probably is porous. The first row consists of teeth with a base flat and broad (Fig.8). The next row below consists of longer curved teeth but the basis are not so broad as in the caes of the first row. The third row consists of very long teeth with graceful curvature pointing first outwards next upwards and then backwards. They form the lower most row. All the teeth are set at the proper angle that all the rows meet a surface at the same time.

Sections passing through the lamellae where the teeth are set show that each tooth is surrounded by a space and there is a cavity below it which when filled with fluid would push the tooth out. Houy laboriously explains that the teeth are not true teeth evidently comparing them with our own because he refers to pulp cavity and dentine. They no doubt are solid structures but they do not pass insensibly into the substance of the bony tooth plate the statement "so that any kind of movement is out of question" quoted from the official translation provided by INSDOC, cannot stand criticism. Moreover when the lamellar bar is boiled the teeth drop out. This cannot happen if the teeth are continuous with the substance of the bone.

Accrodont dentition has been described for lizards where the teeth are solid and continuous with the jaws. It is not only the case that cavities are here present below the teeth, the cavities can be traced to channels in the lamella. My findings are that the teeth are not connected by bone with the lamellar bar and are moved by hydraulic arrangement.

**Basal plates**

Below the lamellar bars the basal plates are arranged along the median line in a series. The first of these which is behind the lamellobasal is relatively smaller and as we move backwards they increase till about the 18th plate and then again decrease in size up to the 24th. A typical basal plate (stirrup shaped bone of Houy) (Fig. 12) consists of a central expansion from which bridges point outwards and meet a very much broadened plate which is marked off into two regions, by a ridge. The part in front is more or less transparent and covers the hind region of the plate in front when the plates are not disturbed as seen from the dorsal view. Towards the inner edge of the ridge a flat projection arises which is of the nature of a clasp. In the normal position the outer part of the lamellar bar passes below the clasp.

The central expansion (Fig. 13) is more or less transparent and has a rounded lobe which articulates with the hind region of the central plate in front. Close to its lower border a transverse slit is present which leads into a conical cavity within which a pair of ligaments arise. The hind margin is prolonged into a pointed process projecting backwards. The other ends of the ligaments meet the lamellar bars towards their inner ends and on their underside. Between the central plates and the lateral plates there is an arched space which serves for the accommodation of the hook of the lamellar bar.

In the ventral view (Fig. 14) the hind part of the lateral plate has innumerable openings along its outer border arranged in tiers which lead into tubes some of which coalesce to form bigger tubes and open finally by small openings along the inner border of the plate. The central expansion has ridges to provide attachment for the muscles joining it with the spine-like bones below.

The first basal plate has the bridge connecting the central expansion with those of the lateral projecting slightly forwards. The posterior part of the lateral plate is very much broader and has the openings arranged in tiers. The clasp of the plate is strongly made. In the dorsal view the slit for the insertion of the ligament is clear and from the central plate a distinct process points backwards.

In the last basal plate (Fig. 15) the lateral portions are very much broader. There is no distinct division of it into transparent and non-transparent portions. In fact the outer margin has openings arranged in tiers almost along its entire length. The clasp is less pronounced and looks more like a spur.

### Basistruts

Below the basal plates a median row of interneurals are arranged which are the basistruts. The very first basal strut is as we have already mentioned fused with the lamellobasal by its front end. The others are free except for the last two or three of the posterior shield. The dorsal view of a typical free basistrut (Fig. 16) has a prominence in front by means of which it is attached to the central expansion of the Basal plate. It then broadens out into two wings on which there are two depressions with oval callous areas in each of them. Muscles fit into the depressions surrounding the callus and seem to pass between the central expansions of the Basal plates through gaps between them and reach the lamellar bars where similar callus is found. This suggests that the two parts rub against each other and the callus itself is caused by such rubbing.

Behind the wing like expansions there is a slight flattening of the strut which is the part in contact with the median expansion of the Basal plate after which it runs back as an elongated spine. The length of the spine varies with the position it occupies in the disc. In the front region the disc is seated over a cup like depression on the top of the skull and therefore the spines are progressively longer but once the skull region is crossed spines decrease in size until the one at the hind region just before the posterior shield begins, is the shortest. The Basistruts below the posterior shield differ in that their spines are flattened from side to side and they are attached to each other more closely that movement between them is practically nil. The spines of the other Basistruts overlap each other so that three or four of them may appear in a cross section made. Sections also show that a hollow channel is present within the substance of the strut in the anterior flattened portion. Whether these are continuous from spine to spine is not clear.

In the ventral view the prominence in front is distinct and the wing like expansions are convex with no callus in them. In the dorsal view of the same region the callus leads into a funnel shaped portion. The two funnels seem to meet in the centre whether they have any connection with the longitudinal hollow channel is not certain.

While discussing the functioning of the spine like Basistruts Houy maintains that they represent fixed points. This is something that must be carefully noted as it looks as though they are fixed at times and movable at others.

## *Summary.*

The present paper supplies the following new information :—

(1) The four skeletal pieces at the hind end are described in greater detail.

(2) For the first time the presence of the Basilid is recognized and described.

(3) The Lamellobasal at the front end has received special attention.

(4) The tactilodact has been described as a separate entity.

(5) The subtactilodacts hitherto unrecognized are emphasised.

(6) More attention is paid to the openings and tubes in all the bones.

(7) In a general way every skeletal element is critically examined.

## *Acknowledgments.*

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## *List of Illustrations.*

**Fig. 1** .. The skeletal parts of the disc disarticulated and mounted in the correct order with the dorsal side up (the very fine tactilodacts are omitted).

*Left row*—Basal plates (with modified pieces at the front and hind ends).

*Middle row* :—Basistruts.

*Right row* :—Lamellar bars.

**Fig. 2** .. Pyriboss (dorsal and ventral views) L.O. large opening S.O. small opening S.P. spout T. tubes.

**Fig. 3** .. Cross section of Pyriboss (stained Microphotograph). C.C.—Central Cavity D.W.—Dorsal wall. P.—Pulvinus, S.W.—Side Wall with chambers, V.W. —Ventral wall.

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**Fig. 6** .. Basilids—Ventral and Dorsal Views, B.—Bulge; CH.—Channel, CL.—Cleft, M.—Margin, T.—Tubes.

**Fig. 7** .. Basiplatt—Ventral and dorsal views, F.P.—Frontal process; M.C.—Median Canal. Arrow points to openings arranged in tiers.

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**Fig. 9** .. Lamellobasal (Dorsal View), C.—Callus, Sp.—Spine.

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**Fig. 11** .. Lamellar bar (dorsal and ventral views), B.—Bulb like swelling, Br.—Bridge, C.—Callus, H.—Hook, —points to openings on the hook and to two large spaces above and below the bridge.

**Fig. 12** .. First basal plate, B.—Bridge connecting the central plate with the lateral plate; C.L.—Clasp; C.P.——Central Plate, L.P.—Lateral plate; P.P. Posterior process, SL.—Slit.

**Fig. 13** .. Typical basal plate (dorsal view), B.—Bridge connecting the Central plate with the lateral plate, C.L. —Clasp, C.P.—Central plate, L.P.—Lateral plate.

**Fig. 14** .. Typical basal plate (Ventral view), B. Bridge connecting the central plate with the lateral plate, CL.—Clasp, C.P.—Central plate, L.P. Lateral plate. Arrow points to openings arranged in tiers.

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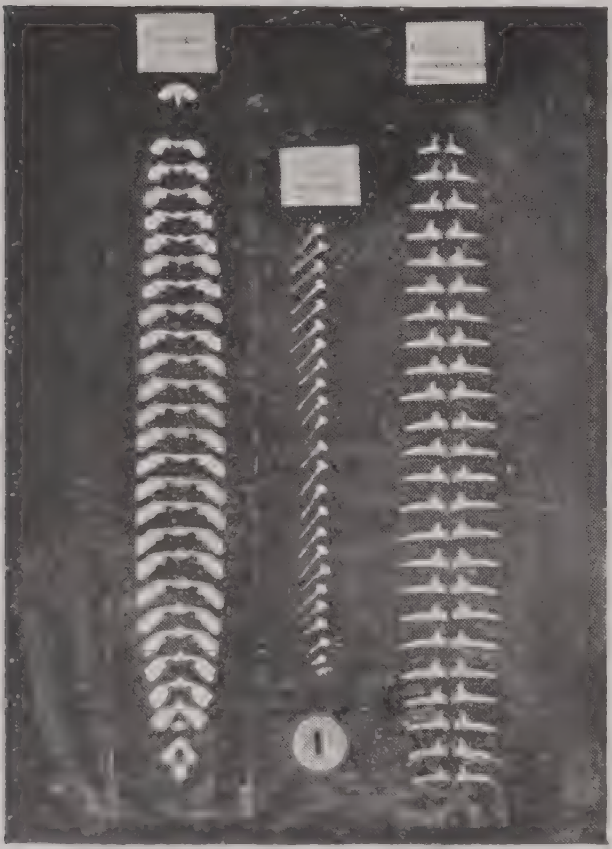
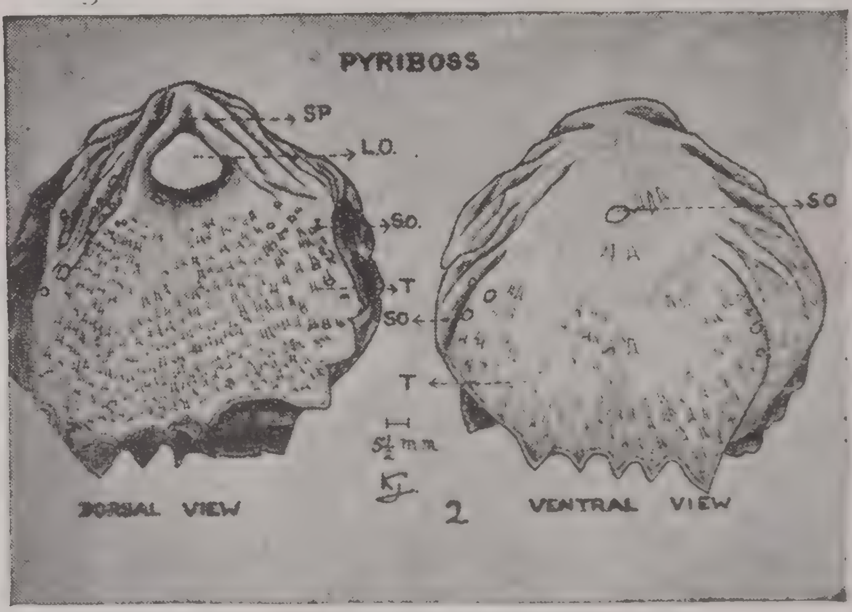
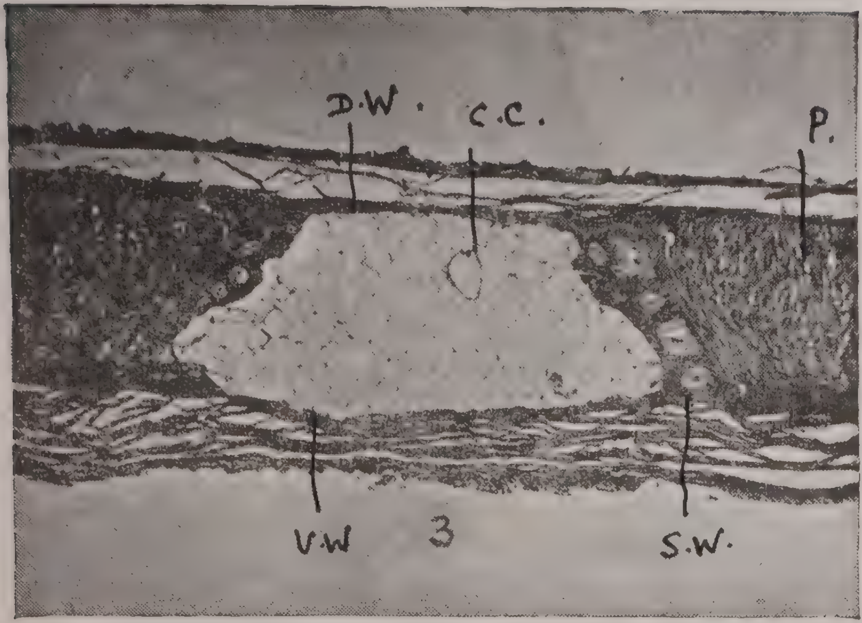
**Fig. 16** .. Typical basistruts and last three Basistruts, C.—Callus, Sp.—Spine, W.—Wing like expansion.



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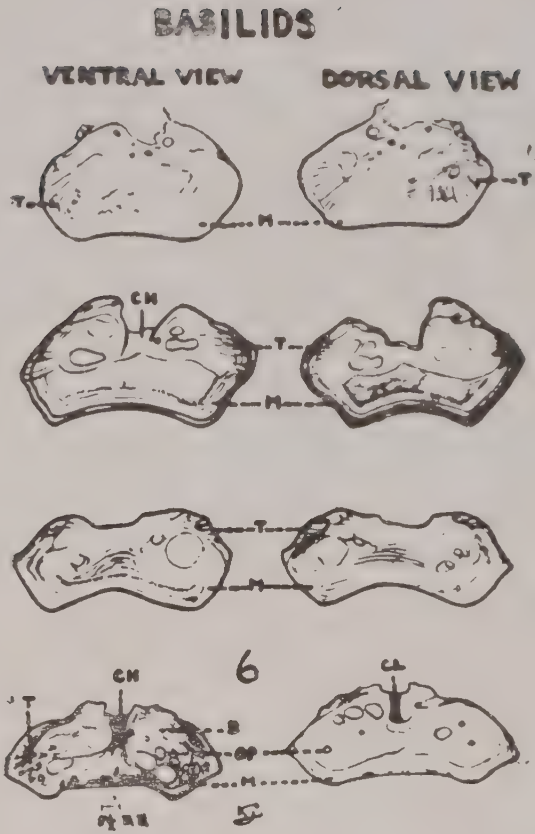
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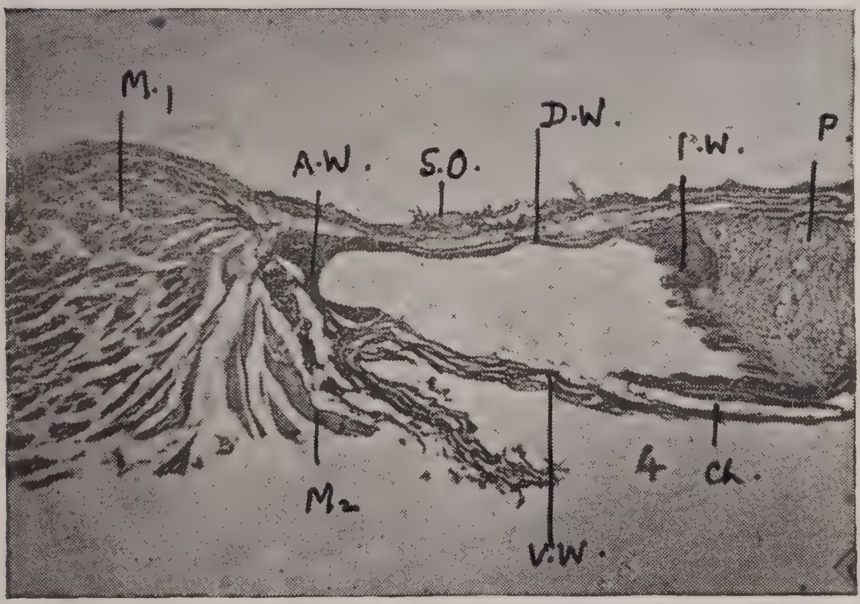
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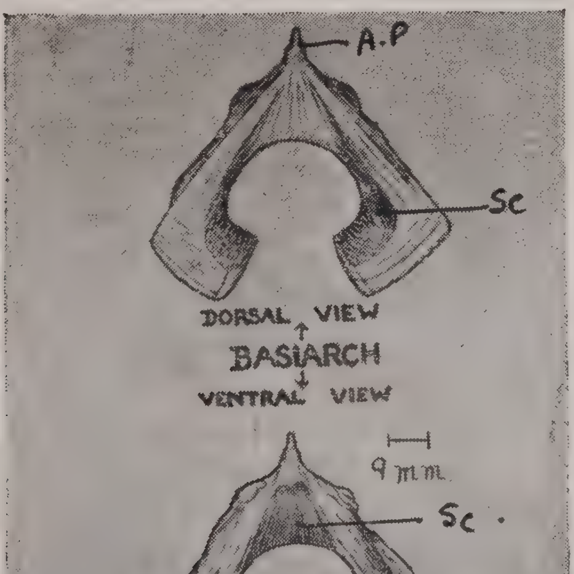
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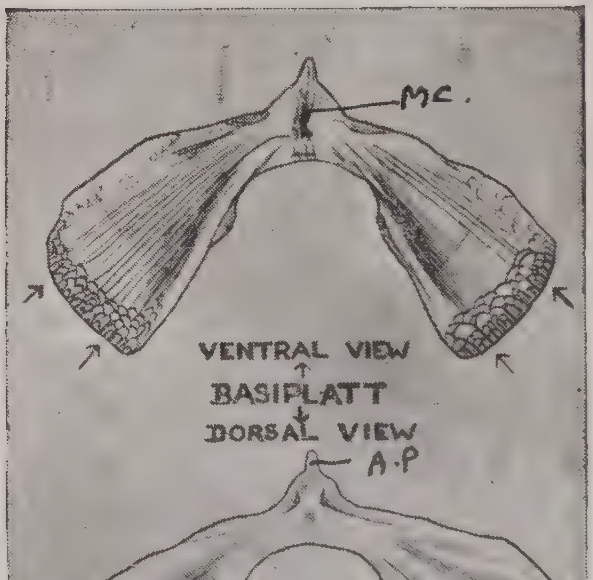
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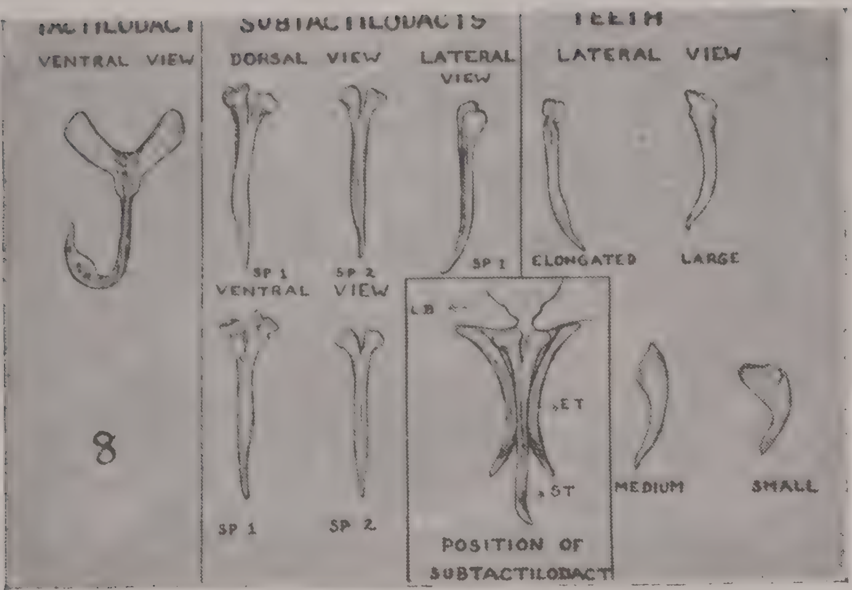
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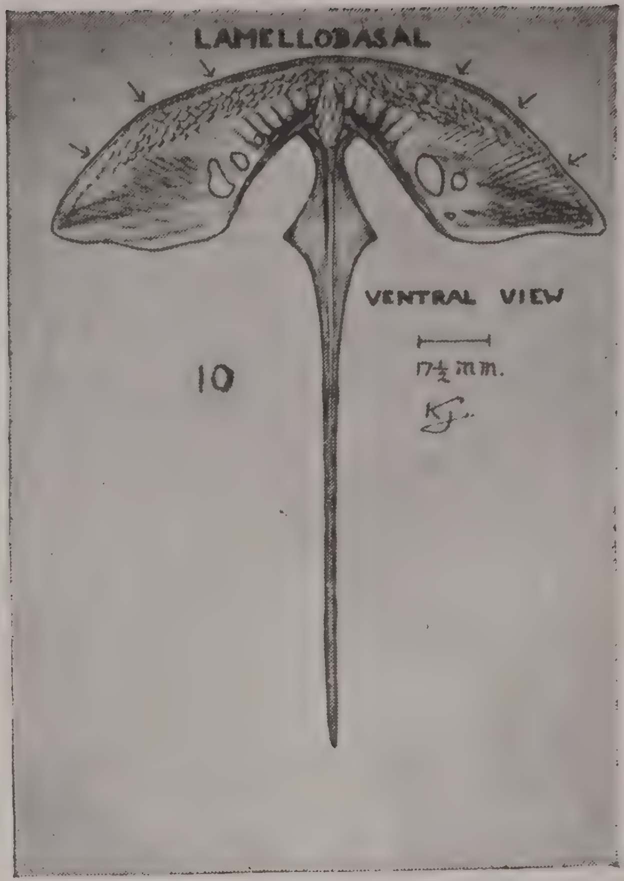
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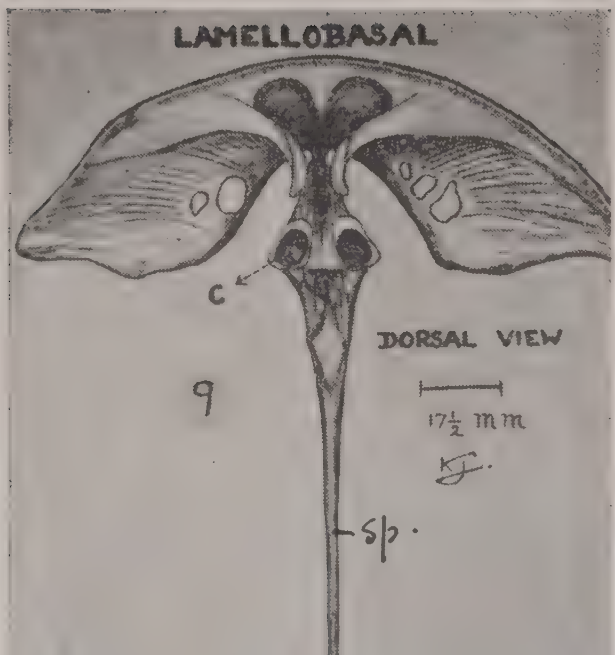
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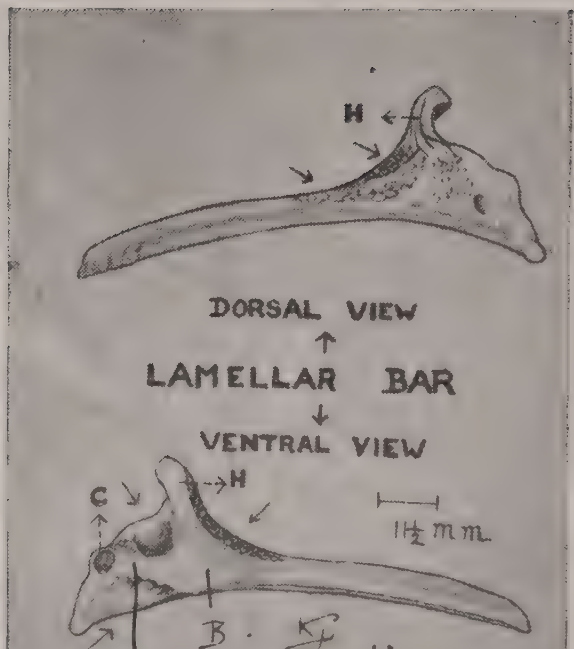
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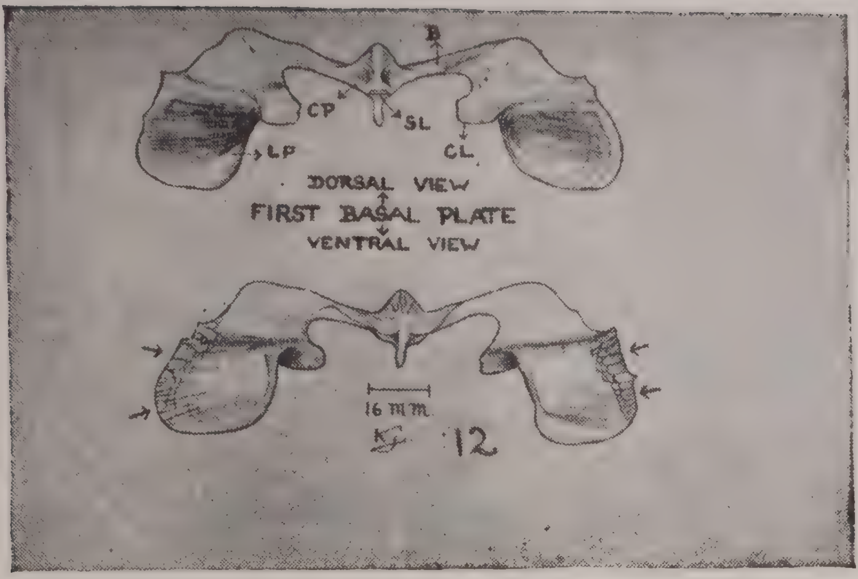
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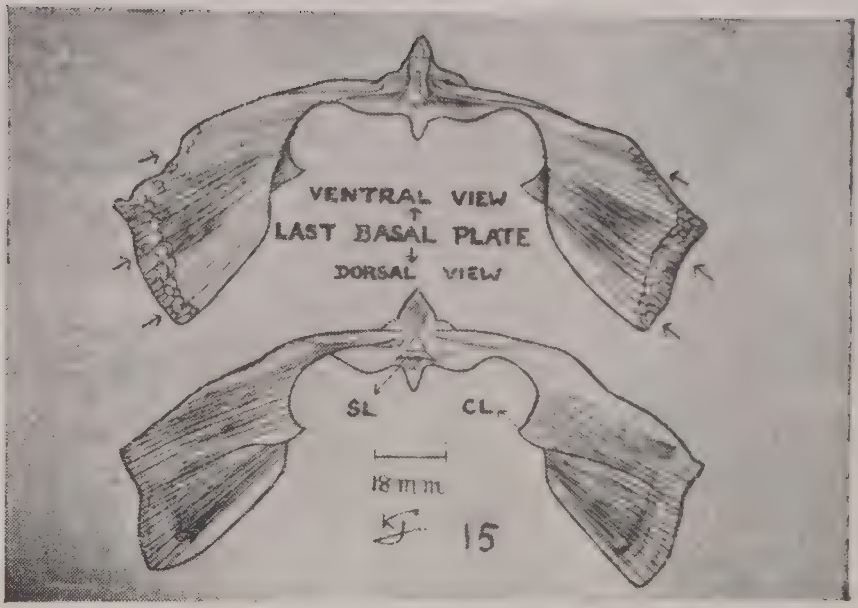
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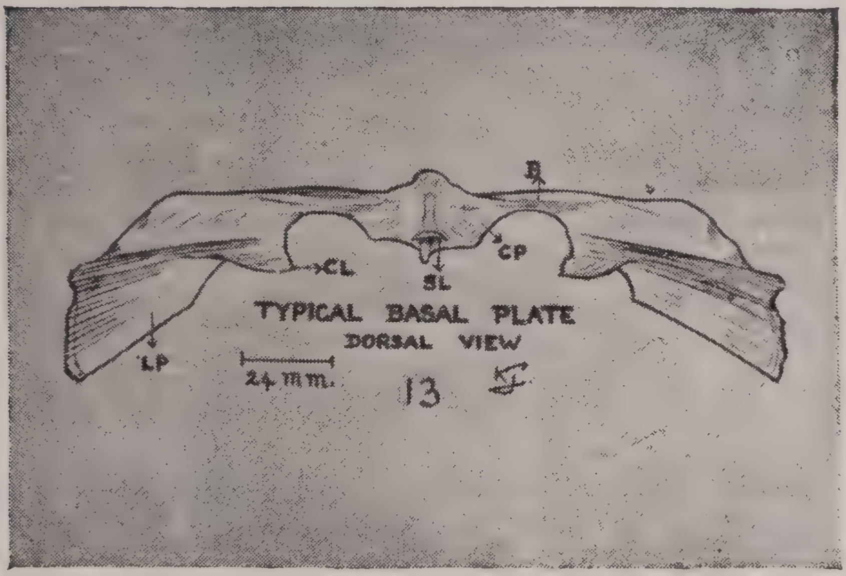
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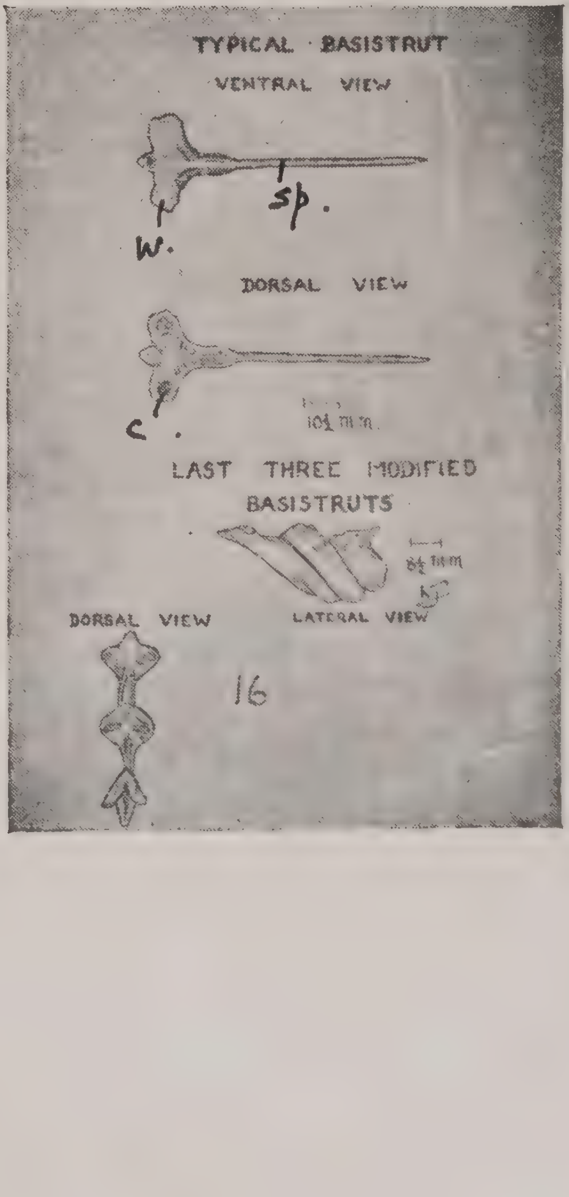
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DORSAL VIEW
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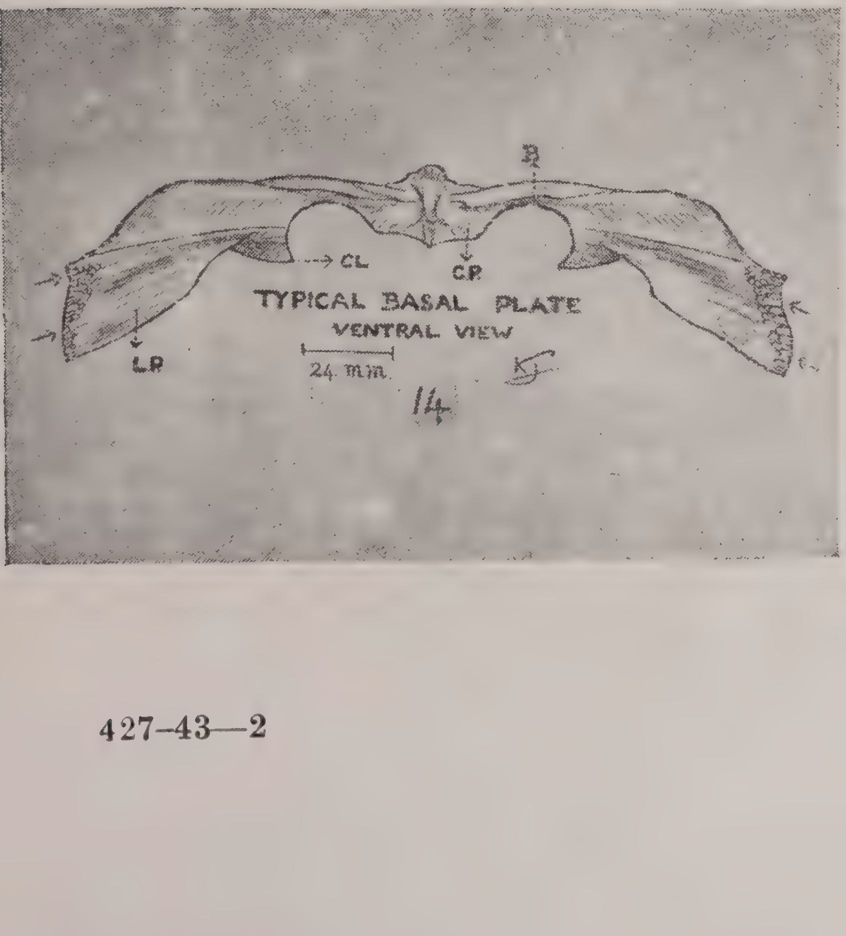
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# ON THE LARVAL STAGES OF IRONA ROBUSTA

BY

Mrs. J. G. ABRAHAM, M.Sc.

The marsupium of the female I. robusta is packed with 200—325 larvae. Larvae of both stages (Pullus stadii primii and Pullus stadii secondi) were observed and described here. This is the second detailed description of larvae of any species of Irona.

### Pullus stadii primii

This larva ranges from 2·75—3·06 mm. in length—

L 2·75×0·83 mm.
Head 0·316 mm.×0·375 mm.
Thorax 1·25 mm.×0·83 mm.
Abdomen 0·75 mm. long.
Telson 0·5 mm.

The larva (Fig. 1) is more than thrice longer than broad measuring 2·75×0·83 mm. and is slightly grey in colour. As in I. far and I. renardi the larva here also look slightly asymmetrical. The cephalon is broader than long and is nearly one fourth the length of the thorax from the broad anterior end of which the antennal pairs are seen. The eyes are narrow 2 mm.×0·1 mm. granular and occupy part of the lateral margin of the cephalon. The thorax is markedly wider than the abdomen but unlike in that of I. far, here the abdomen is much shorter than the thorax. The broadest region of the thorax is at the third, fourth and fifth segment. The last thoracic segment is without limbs as usual and is nearly half the length of the sixth thoracic but broader than the abdominal segments. The Epimera are flabby and not clearly indicated at this stage.

The last two abdominal segments are markedly longer than the proceeding three segments. The Telson is 0·75 mm. long roughly shield shaped with a broader anterior margin and gently rounded posterior margin. There is no sub apical constriction in the Telson as is found in the larva of I. foveolata.

### Appendages

The antennules (Fig. 2) are eight jointed and blunt tipped. The antennae (Fig. 3) are nine jointed and more pointed at the tip.

The mandible (Fig. 4) is 0·32 mm. long and consists of a three jointed palp and an inner blunt process which develops into the quasi molar of the adult.

The I maxilla (Fig. 5) is about 0·2 mm. long and is a simple appendage with one blunt spine at its tip. The II maxilla (Fig. 6) is 0·15 mm. long is just unequally bilobed with an outer broader and inner narrow lobe, both without spines.

The maxilliped (Fig. 7) is 0·23 mm. long is three jointed of which the second is the largest. The terminal joint bears a tooth. The six pairs of thoracic limbs (Figs. 8—10) are long. Each of the thoracic appendages is provided with long and simple distinct nail or claw. The seventh thoracic segment is without any appendage as usual. The pleopods (Fig. 11) have a two jointed protopodite with the basipodite showing four short rudimentary setae in the beginning stage of development. Pleopods of I stage larvae showed setae in different stages of development. The rami are non-setose just wavy with the outer broader and very slightly longer than the inner one. The Uropods (Fig. 12) are longer than the telson, with a long protopodite, shorter endopodite and much longer exopodite.

### Pullus stadii secondi

The larva (Fig. 13) has grown to about 3·06 mm. by now. The greyish colour is more prominent. At this stage the head is 0·431×0·562 mm., and broader than long. The most important feature in the head is the eyes. The eyes have become nearly four times broader than in the 1st stage appear much darker in colour, and fill almost the entire length of the lateral margins of the cephalon. The thorax is not so markedly broad as in the 1 stage larva. The last segment is markedly shorter than the rest. The third and fourth segments are longer than the first two and the fifth, and sixth and the last much shorter than the sixth segment of the first pleon segment. The epimera are flabby and marked faintly on the thoracic region. The uropods are setose with distinct statocyst like organs on their exopodites and the anterior three pairs of thoracic limbs are provided with serrated dactyli, the posterior 3 showing simple claws as in the larva of the first stage.

The antennules (Fig. 14) have become much elongated and are provided with sensory papillae. The terminal joint is provided with a tuft of 8 aesthestasc of which 4 are short and the other 4 are much longer. The outer distal margins of seventh, sixth and third segments of the antennule also bears one short seta each. In addition to the seta, the third segment shows a few hairs. The II antennae (Fig. 15) has slightly increased in length and carries at the distal outer margin of fifth, seventh and eigth segments a seta each. The tip of the distal segment is also setose. The mandible (Fig. 16) does not show much difference from that of first stage larva except in that the simple club shaped structure is slightly getting modified into a quasi molar. The I maxilla (Fig. 17) which was simple in the first stage shows 3–4 teeth at its tip. The *II maxilla* (Fig. 18) at this stage the inner smaller lobe has become more prominent and slightly anterior in position than the outer lobe, and shows 2 sharp slightly curved teeth at its inner margin.

The maxilliped (Fig. 19) does not show much change at all. Most probably the quasi molar of mandible and the teeth of maxillae and maxilliped appear in a later stage in this larva.

The thoracic appendages (Figs. 20—23) show marked difference from the first stage larva. The simple less curved nails of the 1st stage larva have become much elongate and curved showing a very fine narrow pointed tip. Such hooked claws are an adaptation for clinging to any suitable host. In the first 3 pairs, the proximal half of the inner margin of the dactili show 5 to 7 short conical teeth. The dactili of the last three pairs (Figs. 22 and 23) are simple and curved and do not show the serrations. The propodi of the first three pairs and the last show 3 short rather curved teeth in their inner margin. That of the fifth pair (Fig. 22) show two teeth near the dorsal region of the dactylus.

The carpus of the third and sixth (Figs. 21 and 23) show 1 and 2 spines. The merus in sixth pair also shows a spine externally at the distal region (Fig. 23). Such spines in addition to hooked claws seem to be an adaptation for clinging on to a suitable host.

The pleopods (Fig. 24) are all similar. The distal margin of the endopodite shows 7 pinnate setules. The expodite is devoid of such setules.

The uropods (Fig. 25) show a marked change. The endopodite bears 17 pinnate setules of which the two at the outer margin are very much shorter than the rest. The expodite is devoid of setules at the outer margin but bears at its inner margin nine long pinnate setules two simple short setules and one thick inwardly curved spine. Of the nine pinnate setules, the one nearest to the two simple setules is shorter than the other eight.

## Statocysts

As in the pullus stadii secondi of I. far the exopodite of the uropods of this II stage larvae show distinct statocysts. They are oval in structure and are present in the middle of the exopodite. They do not seem to open to the exterior but muscle structure seem to pass inwards and support a statolith like mass in the centre. These are never observed in the I stage larva or adult. Evidently they seem to develop at this state of the life history but disappear after they get attached to a host.

In I. renardi eight such pinnate setules and a few thick hairs and a sting are mentioned.

In I. nanoides Stebbing does not mention anything about the number of pinnate setules in the expodites of the uropods.

In the II stage larva of I. far the endopodite shows 15 pinnate setules and exopodite shows 10 such pinnate setules and two straight stings at the distal margin external to these—of which the inner one is longer than the outer.

The larvae of II stage apart from its appearance and size differs from the larva of I stage in the general shape of the body structure of all the cephalic appendages, first 3 pairs of thoracic appendages, the pleopods and uropods and also in the occurrence of statocysts in the exopodite of the uropods.

From 2·5 mms. it grows to 3·75 mms. The shape is much narrower and elongate—the thorax very slightly broader than the abdomen. The larva looks striated transversely faintly. The hitherto scattered pigment cells arrange themselves in transverse rows along the outer and posterior margins of the segments.

### *Explanation of figures.*

| *Figure number.* | | |
|---|---|---|
| 1 | Larva I Stage of I. robusta | 5 × 80 |
| 2 | Antennule | 5 × 40 |
| 3 | Antenna | 7 × 40 |
| 4 | Mandible | 7 × 40 |
| 5 | I Maxilla | 7 × 40 |
| 6 | II Maxilla | 7 × 40 |
| 7 | Maxilliped | 15 × 8 |
| 8–10 | Thoracic legs First, second and third | 5 × 8 |
| 11 | A pleopod of I stage larva | 5 × 8 |
| 12 | Uropod | 5 × 8 |
| 13 | Larva of II stage | 5 × 8 |
| 14 | Antennule | 5 × 40 |
| 15 | Antenna | |
| 16 | Mandible | 5 × 40 |
| 17 | I Maxilla | 5 × 40 |
| 18 | II Maxilla | 5 × 40 |
| 19 | Maxilliped | 5 × 40 |
| 20 | I Thoracic leg | 15 × 8 |
| 21 | Third Thoracic leg | 15 × 8 |
| 22 | Fifth Thoracic leg | 15 × 8 |
| 23 | Sixth Thoracic leg | 15 × 8 |
| 24 | A pleopod | 5 × 8 |
| 25 | Uropod | 5 × 8 |

### *Key to Lettering.*

| | | |
|---|---|---|
| 1 | A. | Antennule |
| 2 | Ab. | Abdomen |
| 3 | Ant. | Antenna |
| 4 | B. | Basis |
| 5 | C. | Cephalon |
| 6 | Cl. | Claw |
| 7 | Ca. | Carpus |
| 8 | Dt. | Dactylus |
| 9 | E. | Eye |
| 10 | En. | Endopodite |
| 11 | Ex. | Exopodite |
| 12 | Irch. | Ischwin |
| 13 | Mdb. | Mandible |
| 14 | Mc. | Merus |
| 15 | Mx. | I. Maxilla |
| 16 | Mx. II | II Maxilla |
| 17 | Mxp. | Maxilliped |
| 18 | Prt. | Protopodite |
| 19 | Prp. | Propodus |
| 20 | Pl. | Pleopod |
| 21 | Sp. | Spine |
| 22 | T. | Telson |
| 23 | Th. | Thorax |
| 24 | Upd. | Uropod |

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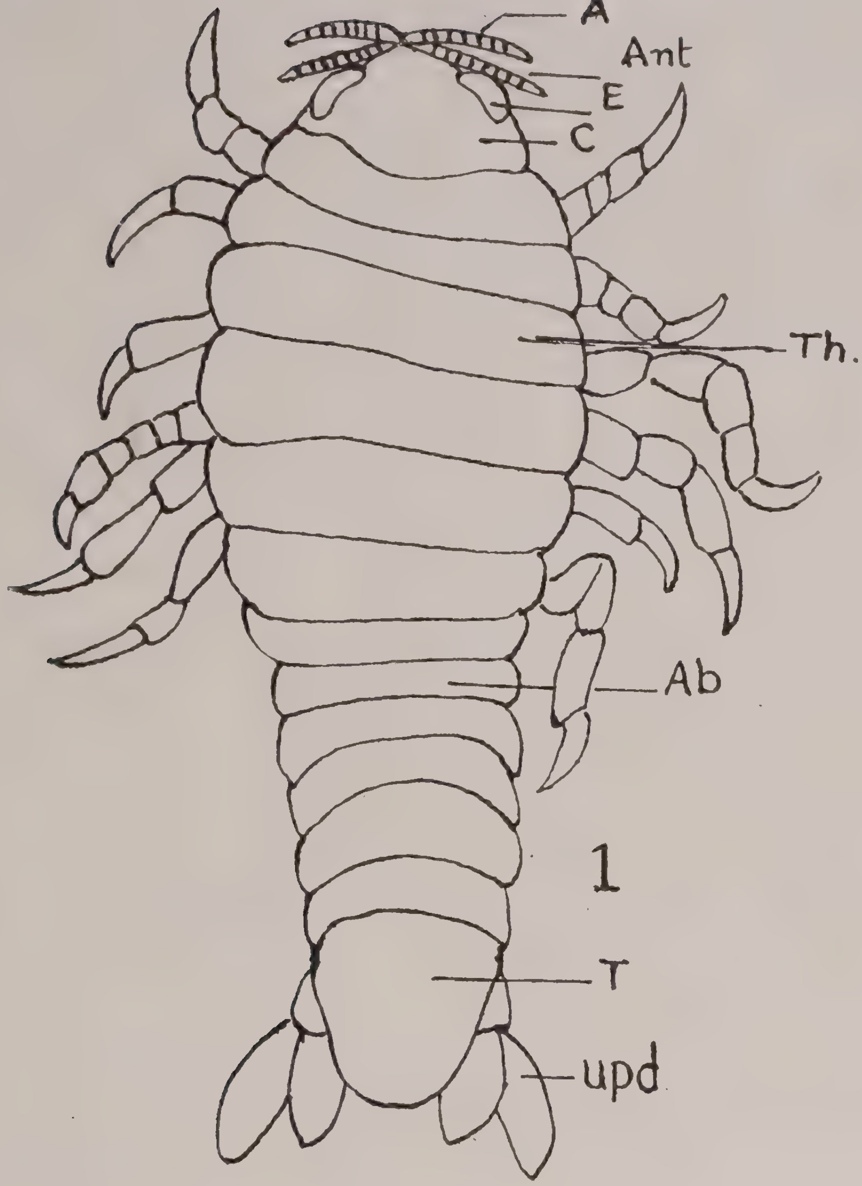
Pl. I



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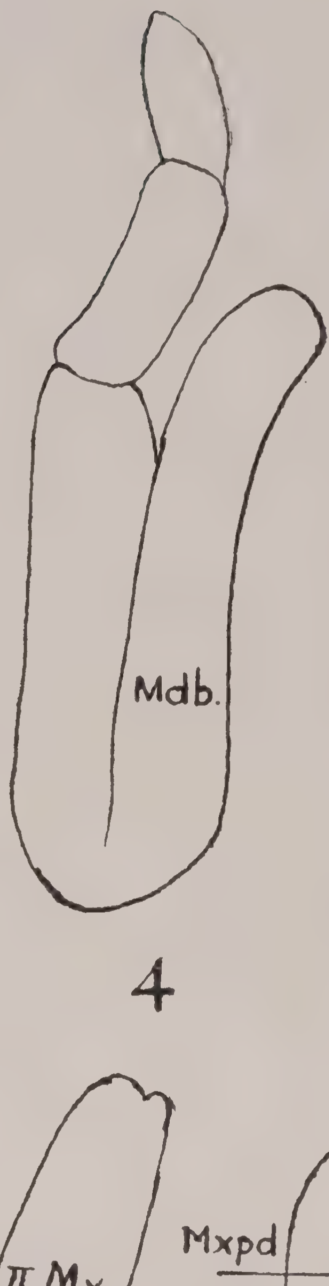

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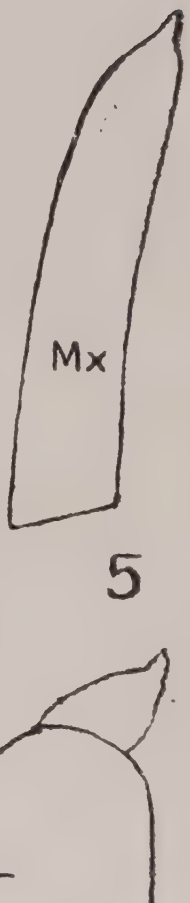

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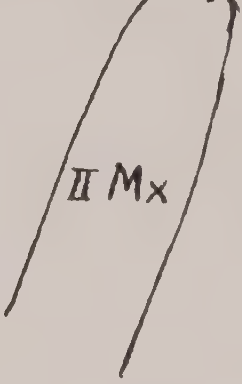

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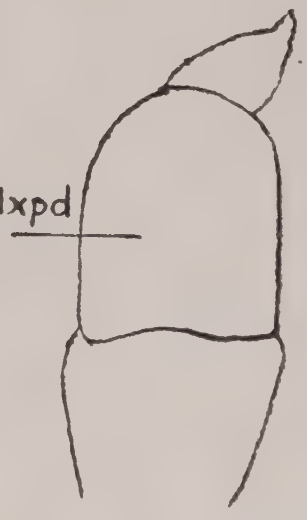

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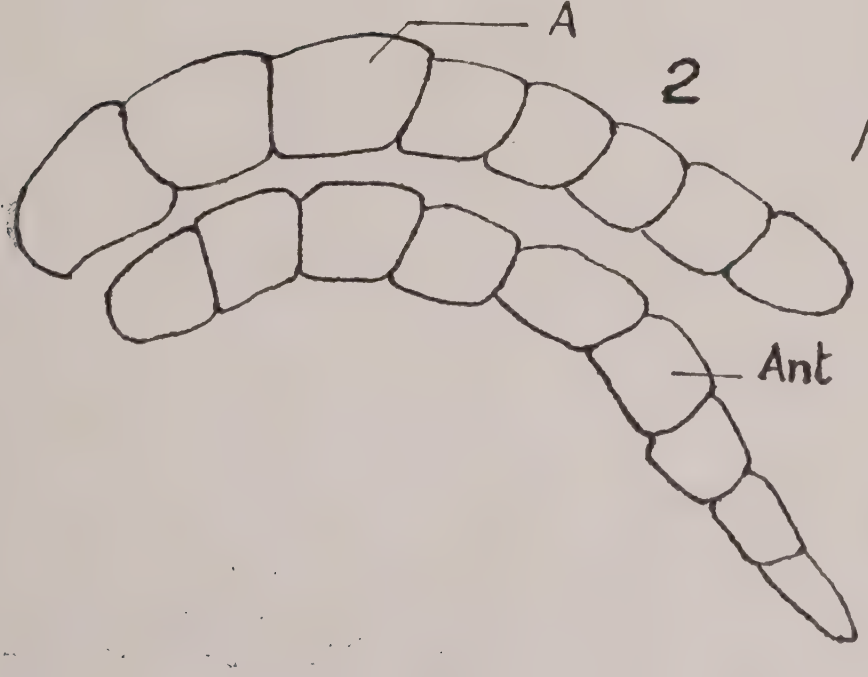

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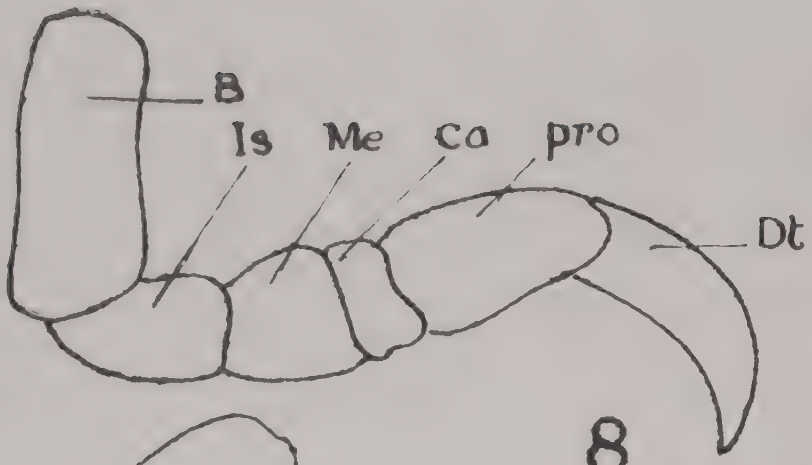

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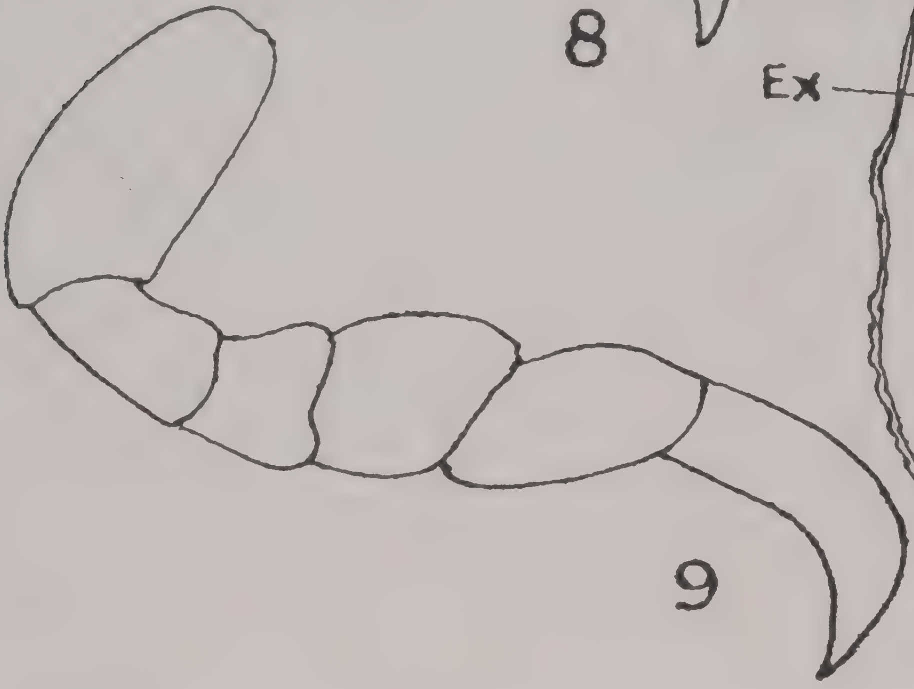

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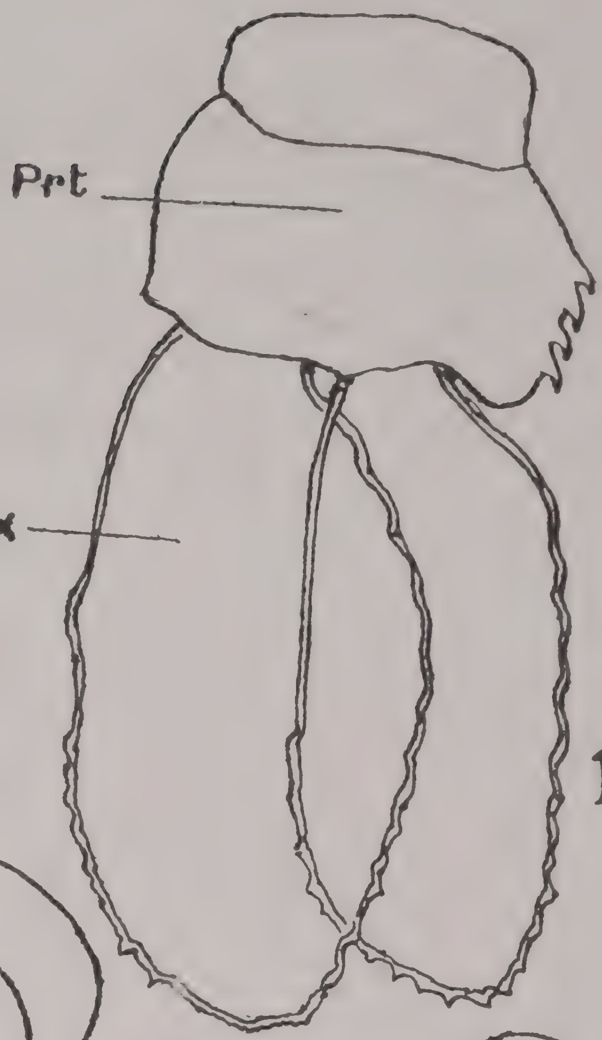

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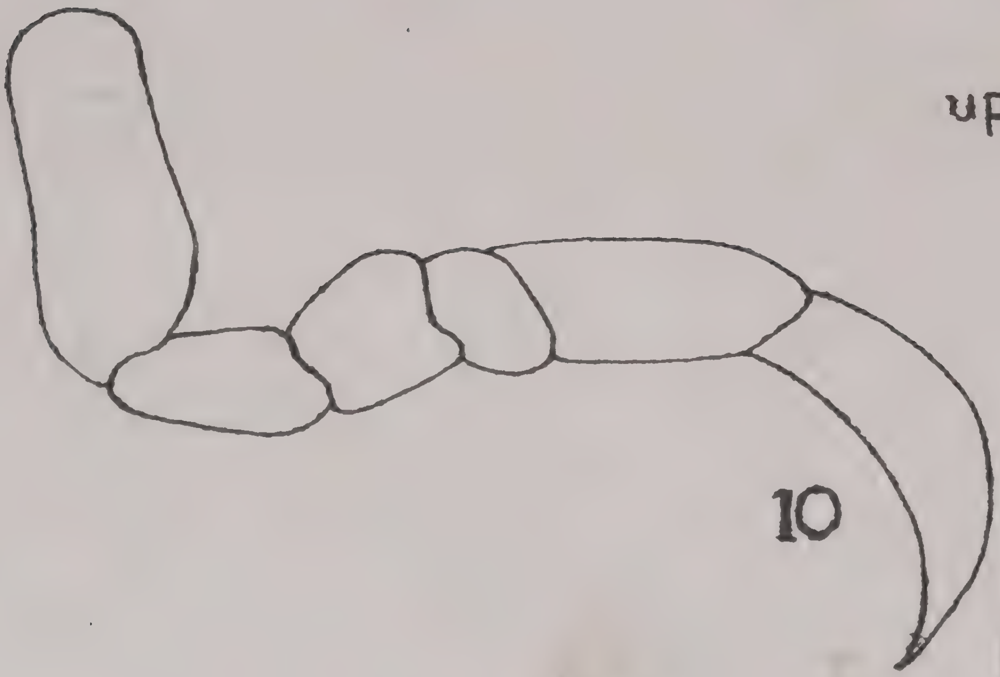

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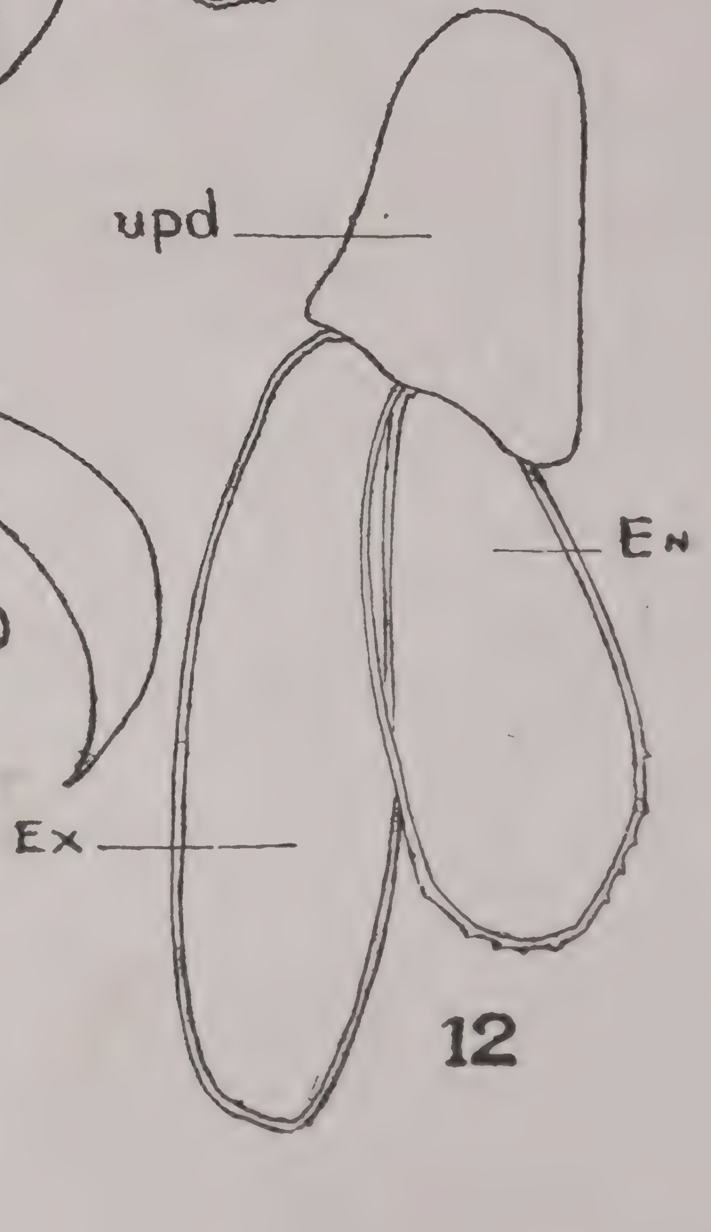

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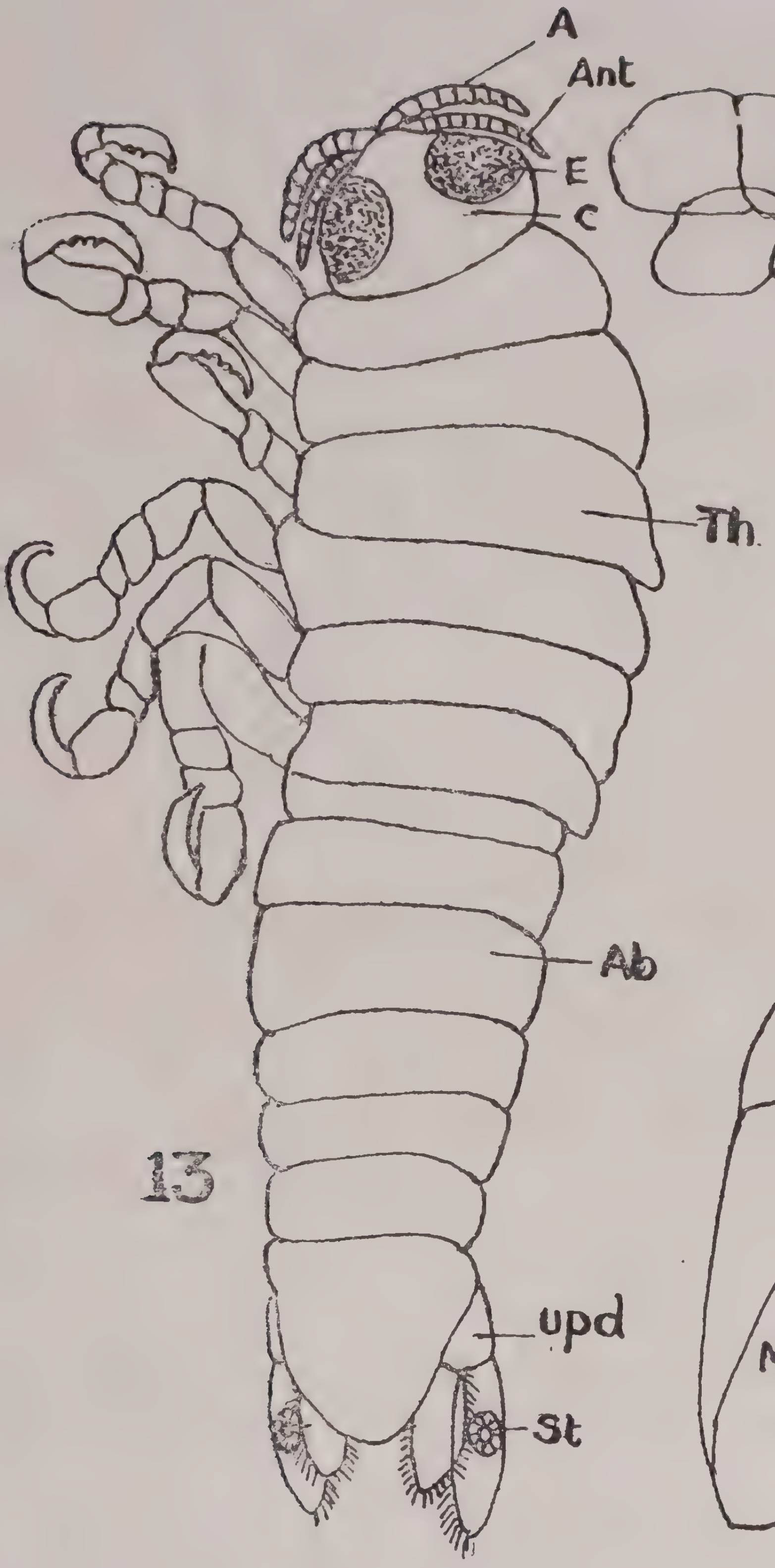

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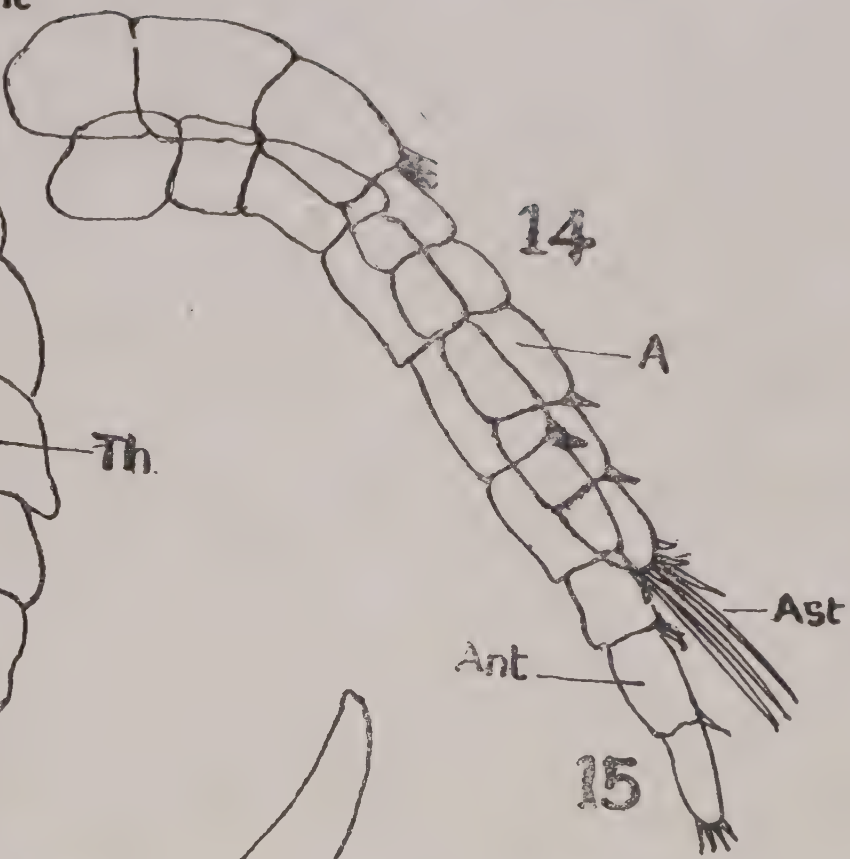

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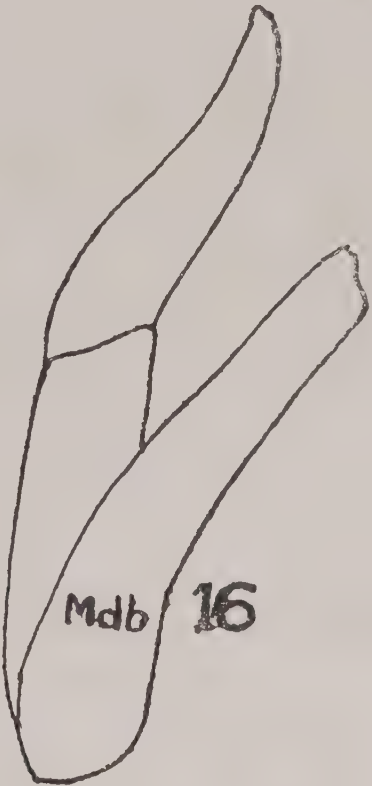

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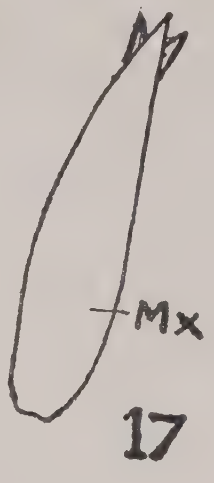

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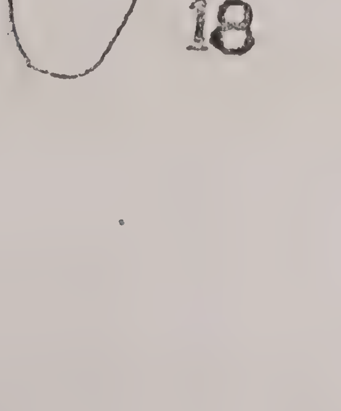

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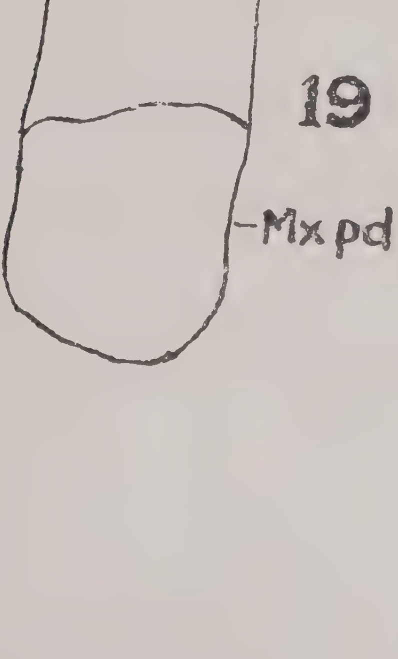

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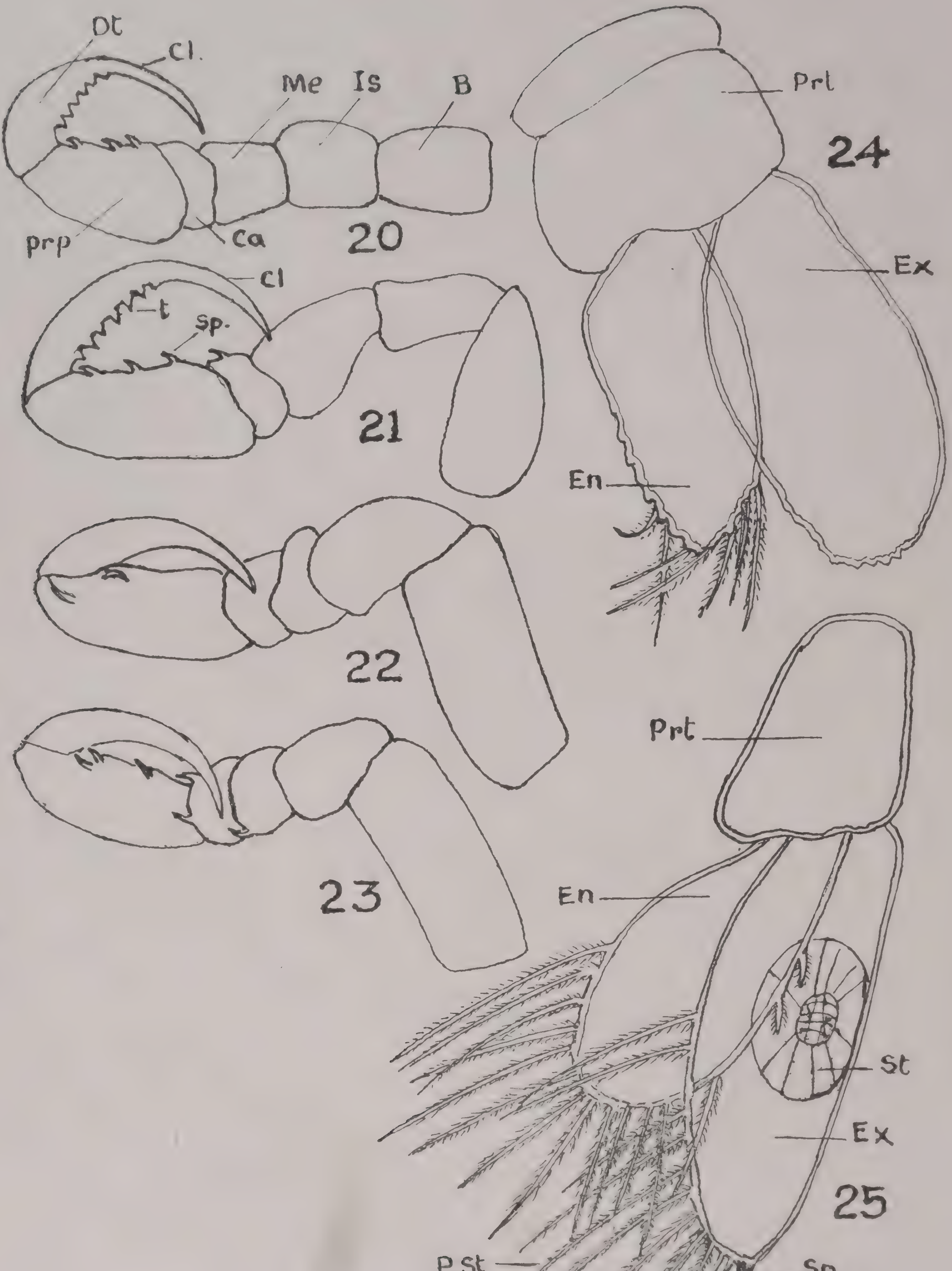
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# USE OF CHLORTETRACYCLINE AS A PRESERVATIVE FOR DRY SALTED FISH-II

BY

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## Introduction

In an earlier communication by one of the present authors (Joseph, K.C., 1962) the results of experiments on the effects of chlortetracycline in prolonging the useful shelf life of four species of dry salted marine fish were reported. The results of similar investigations on six other species of marine food fishes are incorporated in this paper.

The results of studies carried out on the effect of the same antibiotic at lower levels than used in the previous investigations for the preparation of dry-salted Sardines are also presented in this paper.

## Material and Methods

The studies were carried out with the following species of fishes :—(1) Trichiurus savala, (2) Sciæna sp., (3) Lactarius lactarius, (4) Chirocentrus dorab, (5) Serranus sp., (6) Arius sp. and (7) Sardinella sp. The raw material was procured from the freshly landed catches at Cape Comorin. Acronize B1, a product of the American Cyanamid Company was used for the C.T.C. preparations tried in these experiments. The freshly purchased specimens were washed clean, first with sea water, then with fresh water and processed as follows :—

(1) *Trichiurus savala.*—The specimens were slit open along the dorsal side and gutts and gills removed and a few transverse incisions made on both the sides to facilitate penetration of C.T.C. and salt. Those were then cleaned by washing in fresh water and kept immersed in 25 p.p.m. C.T.C. for 5 minutes, drained and salted, the salt : fish proportion being 1: 5 by weight. The salted fish was then kept aside in a closed cistern so as to remain in contact with the self-brine formed for 24 hours. After the curing period of 24 hours, the salted material was removed, drained and dried for three consecutive days in the sun, over bamboo barbecues. A control sample was prepared under identical conditions but for the dip in the C.T.C. solution.

(2) *Sciaena sp.*—The process was the same as for Trichiurus described above, but for the filletting of the specimens by longitudional cuts and the use of a higher salt fish ratio of 1: 4.

(3) *Lactarius.*—The fishes were slit along the dorsal side and gutts and gills removed. No incisions were made on the flesh. Three different salt fish proportions of 1:3, 1:4 and 1:5 were tried. Other details of processing were the same as for Trichiurus already described.

(4) *Chirocentrus dorab.*—The processing was identical in all respects as for Trichiurus.

(5) *Serranus sp.*—The same method of preparation as given above for Sciæna sp. was employed.

(6) *Arius sp.*—This fish was also cured according to the method described for Sciæna.

(7) *Sardines.*—The specimens were cut open along the dorsal line, entrails removed and washed clean. This material was then divided into four lots, one of which was salted to serve as a control sample, the salt:fish ratio being 1:7. The second lot was given a one minute dip in 5 p.p.m., C.T.C. prior to salting in the same ratio of salt:fish mentioned above. Similarly the remaining two portions were given one minute dips on 10 and 15 p.p.m., C.T.C. respectively before salting in the same ratio. The period under cure for all these was 24 hours followed by sun drying for three consecutive days. The entire experiment was duplicated and the products kept in storage in glass-jars with bakelite screw caps up to six months and periodically examined at monthly intervals for organoleptic and chemical characteristics. The chemical and organoleptic tests were conducted employing the same methods as described in the earlier communication (Joseph, K.C., loc cited).

## Results and Conclusions

The results of the periodic analysis are summarised in Tables I to VI respectively for Trichiurus, Sciaena sp., Lactarius Lactarius, Chirocentrus dorab, Serranus sp. and Arius sp., salted after treatment with C.T.C. at 25 p.p.m. concentration. The results of the experiments on Sardines using lower concentrations of 5, 10 and 15 p.p.m., C.T.C. are presented in Table VII.

The earlier finding that the C.T.C. (25 p.p.m.) treated products of dried salted fish remained in excellent condition for three months as against two months only in the case of the untreated control samples of dried salted Lethrinus, Silver bellies and Sardines was further confirmed as a result of the present investigations carried out with Trichiurus savala, Sciæna sp., Lactarius lactarius, Chirocentrus dorab, Serranus sp. and Arius sp. Further, in the case of those fishes for which more than one salt:fish proportions were tried the C.T.C. treated products had always better organoleptic characteristics and chemical qualities than the corresponding control samples of corresponding stages during the period of storage. This showed that the action of C.T.C. in retarding the growth and multiplication of spoilage-causing bacteria was not affected by the concentration of salt present in the cured fish. This view was further confirmed by the figures for total bacterial count estimated in the case of the cured Serranus, Chirocentrus and Arius products. A further close scrutiny of the data reveals that though lower levels of T.V.B.N., T.M.A. and T.B.C. were recorded in the case of C.T.C. treated samples at all stages, their rate of change on storage were found to be more or less of the same order as in the untreated samples. This may probably be due to the removal of most of the C.T.C. penetrated into the flesh by subsequent salting. However the initial reduction in the T.V.B.N., T.M.A. and T.B.C. accomplished by the C.T.C. dip. prior to salting was definitely found to improve the product and enhance its keeping qualities and shelf life.

Experiments on the curing of sardines using C.T.C. at the lower concentrations of 5, 10 and 15 p.p.m. revealed that the use of the antibiotic at 5 and 10 p.p.m. level had practically no effect on the keeping qualities of the cured products. In these cases the samples did not differ very much from the untreated control samples in respect of chemical characteristics. The differences in the average figures for T.V.B.N. and T.M.A.N. for the three series experiments between the treated and untreated samples are noted below :—

| | *Concentration of C.T.C. used for immersion.* | | | | | |
|---|---|---|---|---|---|---|
| *Period of storage in days.* | *5 p.p.m.* | | *10 p.p.m.* | | *15 p.p.m.* | |
| | *T.V.B.N.* | *T.M.A.N.* | *T.V.B.N.* | *T.M.A.N* | *T.V.B.N.* | *T.M.A.N.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 30 .. .. | 6·5 | 0·25 | 12·75 | 3·25 | 16·0 | 4.25 |
| 90 .. .. | 1·25 | 5·25 | 10·25 | 13·50 | 69·0 | 27·0 |
| 120 .. .. | 1·5 | 2·75 | 8·75 | 9·25 | 53.5 | 25·75 |
| 150 .. .. | 3.25 | 1.75 | 2·25 | 8·50 | 59·25 | 24·50 |
| 180 .. .. | 12·25 | 3·25 | 50·75 | 7.0 | 122.0 | 21·25 |

From these figures it is clear that the samples dipped in 5 p.p.m. and 10 p.p.m. C.T.C. were not better than the control samples. But the samples treated with 15 p.p.m. C.T.C. solution prior to salting exhibited slightly better keeping qualities than the untreated samples. This improvement was however much below what was obtained for the same fish when dipped in 25 p.p.m. C.T.C. (Joseph, K.C., loc. cited). It may therefore be concluded that a dip in 25 p.p.m. C.T.C. prior the salting is beneficial in the salt curing of fish and will improve the quality of the salt cured product and enhance its keeping qualities and shelf life. The method may be safely and profitably adopted in the fish curring industry, as no health hazard is involved, the residual antibiotic being completely destroyed on cooking (Chari, S.T., 1961).

### *Acknowledgment.*

We are grateful to the Director of Fisheries, Madras, for his kind permission to publish this paper.

### *References.*

1 Chari, S. T. (1961)—" Use of aureomycin in fish preservation and effect of heat on the antibiotic treated fish." Proc. Indian Acad. Sci. 1961, 4, 173–181.

2 Joseph, K. C. (1962)—" Use of Chlortetracycline as a preservative for dry salted fish-I ". Madras Journal of Fisheries, 1962, 1, 129–133.

TABLE I.

*Data on progress of spoilage in Trichiurus Savala cured with salt after treatment with C.T.C.*
*(Salt : Fish 1: 5).*

| *Storage period sample.* | *30 days.* | | *60 days.* | | *90 days.* | | *120 days.* | | *150 days.* | | *180 days.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Moisture (per cent) .. .. | 36·02 | 36·04 | 36·24 | 36·16 | 36·40 | 36·34 | 36·28 | 36·30 | 36·45 | 36·42 | 36·01 | 36·00 |
| TVBN (mgm./cent) .. .. | 94·00 | 82·00 | 102·00 | 84·00 | 117·50 | 97·00 | 122·50 | 101·50 | 133·50 | 107·00 | 162·50 | 132·00 |
| TMAN (mgm./cent) . .. | 42·00 | 33·50 | 45·00 | 36·00 | 54·50 | 43·00 | 59·00 | 44·50 | 68·00 | 48·00 | 80·50 | 61·00 |
| Organoleptic Test Score (Max. 30). | 30·00 | 30·00 | 29·00 | 30·00 | 29·00 | 30·00 | 28·00 | 29·00 | 25·00 | 28·00 | 23·00 | 26·00 |

*Remarks*—*A*=Control sample.
*B*=Sample treated with C.T.C.

TABLE II.

*Data on progress of spoilage on Sciaena sp. cured with salt after treatment with C.T.C. (Salt : Fish 1 : 4).*

| *Storage period sample.* | *30 days.* | | *60 days.* | | *90 days.* | | *120 days.* | | *150 days.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | B |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Moisture (per cent) .. .. | 39·75 | 40·02 | 39·60 | 39·84 | 38·40 | 38·64 | 37·43 | 37·37 | 37·18 | 37·17 |
| TVBN (mgm./cent) .. .. | 95·50 | 72·50 | 100·50 | 74·00 | 108·00 | 80·00 | 119·00 | 83·00 | 136·00 | 102·00 |
| TMAN (mgm./cent) .. .. | 37·00 | 34·75 | 39·50 | 35·00 | 41·50 | 36·00 | 58·00 | 38·00 | 75·50 | 59·00 |
| Organolephic Test Score (Max. 30) | 30·00 | 30·00 | 30·00 | 30·00 | 29·00 | 30·00 | 27·00 | 29·00 | 26·00 | 28·00 |

*Remarks.*—*A*=Control sample.
*B*=Sample treated with C.T.C.

TABLE III.

*Data on progress of spoilage in Lactarius. Lactarius cured with salt after treatment with Chlortetracycline.*

| *Storage period.* | *Sample.* | *Control.* | | | *C.T.C. Treated.* | | | *Remarks.* |
|---|---|---|---|---|---|---|---|---|
| | *Salt : Fish.* | 1 : 3 | 1 : 4 | 1 : 5 | 1 : 3 | 1 : 4 | 1 : 5 | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 30 days | Moisture (per cent) | 34·43 | 35·05 | 35·23 | 34·61 | 35·12 | 35·17 | .. |
| | TVBN (mgm/cent) | 83·5 | 87·0 | 90·0 | 80·0 | 81·0 | 84·5 | .. |
| | TMAN (mgm/cent) | 32·5 | 32·0 | 36·5 | 30·5 | 31·0 | 31·5 | .. |
| | Total count (no/gm) | 9,300 | 9,500 | 10,100 | 8,700 | 8,100 | 9·000 | .. |
| | Org. Test Score (Max. 30). | 30·0 | 30·0 | 29·0 | 30·0 | 30·0 | 30·0 | .. |
| 60 days | Moisture (per cent) | 34·60 | 35·06 | 35·20 | 34·84 | 35·10 | 35·12 | .. |
| | TVBN (mgm/cent) | 102·0 | 105·5 | 108·0 | 90·5 | 88·5 | 90·0 | .. |
| | TMAN (mgm/cent) | 35·0 | 34·5 | 39·0 | 33·5 | 33·0 | 33·5 | .. |
| | Total count (no/gm) | 13,000 | 17,000 | 16,000 | 10,000 | 9,000 | 11,000 | .. |
| | Org. Test Score (Max. 30). | 28·0 | 28·0 | 26·0 | 29·0 | 29·0 | 29·0 | .. |
| 90 days | Moisture (per cent) | 34·84 | 34·91 | 35·13 | 34·80 | 35·35 | 35·02 | .. |
| | TVBN (mgm/cent) | 154·0 | 150.5 | 162·0 | 121·0 | 116·5 | 123·0 | .. |
| | TMAN (mgm./cent) | 62·5 | 64.0 | 67·5 | 48·0 | 65·0 | 60·5 | .. |
| | Total count (no/gm.) | 81,000 | 86,000 | 93,000 | 27,000 | 30,000 | 28,000 | .. |
| | Org. Test Score (Max. 30). | 25·0 | 25·0 | 24·0 | 27·0 | 27·0 | 27·0 | .. |
| 120 days | Moisture (per cent) | 35·25 | 35·13 | 34·96 | 34·22 | 35·87 | 34·85 | .. |
| | TVBN (mgm /cent) | 230·0 | 242·0 | 250·5 | 232·0 | 193·0 | 203·5 | .. |
| | TMAN (mgm/cent) | 97·0 | 100·0 | 104·0 | 91·0 | 87·5 | 90·0 | .. |
| | Total count (no/gm) | 95,000 | 93,000 | 104,000 | 43,000 | 41,000 | 47,000 | .. |
| | Org. Test Score (Max. 30). | 23·0 | 23·0 | 21·0 | 26·0 | 26·0 | 25·0 | .. |
| 150 days | Moistore (per cent) | 34·81 | 34·65 | 34·02 | 34·08 | 35·42 | 33·60 | .. |
| | TVBN (mgm/cent) | 250·0 | 255·0 | 290·0 | 230·0 | 195·0 | 205·0 | .. |
| | TMAN (mgm/cent) | 103·0 | 98·5 | 120·5 | 92·5 | 87·5 | 89·0 | .. |
| | Total count (no/gm) | 230,000 | 270,000 | 310,000 | 70,000 | 80,000 | 70.000 | .. |
| | Org. Test Score (Max. 30). | 20·0 | 19·0 | 19·0 | 24·0 | 23·0 | 23·0 | .. |
| 180 days | Moisture per cent | 34·84 | 34·73 | 34·09 | 34·30 | 35·50 | 33·55 | .. |
| | TVBN (mgm/cent) | 290·00 | 305·0 | 332·5 | 255·0 | 250·0 | 255·0 | .. |
| | TMAN (mgm/cent) | 115·0 | 115·5 | 131·0 | 97·5 | 91·0 | 105·0 | .. |
| | Total count (no/gm) | 310,000 | 340,000 | 480,000 | 130,000 | 150,000 | 140,000 | .. |
| | Org. Test (Score Max. 30). | 18·0 | 15·0 | 16·0 | 23·0 | 22·0 | 22·0 | .. |

TABLE IV.

*Data on progress of spoilage in Chirocentrus dorab cured with salt after treatment with C.T.C.*
*(Salt : Fish 1 : 5).*

| *Storage period sample.* | *30 days.* | | *60 days.* | | *90 days.* | | *120 days.* | | *150 days.* | | *180 days.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Moisture (per cent) .. .. | 33·26 | 33·16 | 33·09 | 33·28 | 33·34 | 33·67 | 33·30 | 33·21 | 33·42 | 33·37 | 32·59 | 33·22 |
| TVBN (mgm./cent) .. .. | 56·00 | 54·00 | 88·00 | 79·50 | 117·50 | 90·50 | 134·50 | 103·50 | 170·50 | 117·50 | 211·50 | 150·50 |
| TMAN (mgm./cent) .. .. | 24·00 | 23·5 | 35·50 | 32·50 | 43·00 | 38·00 | 45·50 | 38·50 | 61·50 | 53·00 | 66·00 | 62·00 |
| Total count (no/gm.) .. .. | 1,300 | 900 | 49,000 | 13,000 | 57,000 | 17,000 | 80,000 | 40,000 | 1,70,000 | 90,000 | 3,00,000 | 1,20,000 |
| Organoleptic Test Score (Max. 30). | 30 | 30 | 28 | 30 | 26 | 29 | 23 | 27 | 21 | 26 | 19 | 24 |

*Remarks.*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE V.

*Data on progress of spoilage in Serranus sp. cured with salt after treatment with C.T.C. (Salt : Fish 1 : 4).*

| *Storage period sample.* | *30 days.* | | *60 days.* | | *90 days.* | | *120 days.* | | *150 days.* | | *180 days.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Moisture (per cent) .. .. | 38·68 | 39·21 | 37·64 | 38·90 | 37·61 | 38·45 | 37·35 | 37·81 | 36·82 | 37·22 | 37·82 | 37·21 |
| TVBN (mgm./cent) .. .. | 97·50 | 90·50 | 174·00 | 142·00 | 232·00 | 166·00 | 280·00 | 175·00 | 343·00 | 271·05 | 365·50 | 284·00 |
| TMAN (mgm./cent) .. .. | 32·00 | 32·00 | 76·00 | 53·50 | 97·50 | 65·50 | 110·50 | 70·50 | 128·50 | 116·00 | 164·50 | 115·50 |
| Total count (no/gm) .. .. | 7,100 | 6,900 | 31,000 | 11,000 | 48,000 | 19,000 | 83,000 | 31,000 | 2,40,000 | 1,30,000 | 3,70,000 | 1,70,000 |
| Organoleptic Test Score (Max. 30). | 30·00 | 30·00 | 26·00 | 28·00 | 23·00 | 28·00 | 20·00 | 26·00 | 17·00 | 23·00 | 16·00 | 22·00 |

*Remarks.*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE VI.

*Data on progress of spoilage in Arius sp. cured with salt after treatment with C.T.C. (Salt : Fish 1 : 4).*

| *Storage period. sample.* | *60 days.* | | *90 days.* | | *120 days.* | | *150 days.* | | *180 days.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Moisture (per cent) .. .. | 35·97 | 35·41 | 36·13 | 35·59 | 35·61 | 35·30 | 35·34 | 35·08 | 35·41 | 35·72 |
| TVBN (mgm./cent) .. .. | 148·00 | 120·50 | 174·50 | 141·00 | 205·00 | 163·00 | 293 00 | 201·00 | 337·00 | 237·00 |
| TMAN (mgm./cent.) .. .. | 59·00 | 41·00 | 62·00 | 40·05 | 73·00 | 55·00 | 116·00 | 66·50 | 165·00 | 75·50 |
| Total count (no/gm.] .. .. | 24,000 | 9,000 | 13,000 | 13,000 | 67,000 | 22,000 | 260,000 | 60,000 | 4,80,000 | 1,30,000 |
| Organoleptic Test Score (Max. 30). | 27·00 | 28·00 | 25·00 | 28·00 | 22·00 | 27·00 | 20·00 | 25·00 | 17·00 | 22·00 |

*Remarks.*—*A* = Control sample.
*B* = Sample treated with C.T.C.

TABLE VII.

*Data on progress of spoilage in Sardines cured with salt after treatment with C.T.C. (Salt : Fish 1: 7).*

| *Storage. period.* | *Sample.* | *Control.* | | *5 p.p.m. C.T.C.* | | *10 p.p.m. C.T.C.* | | *15 p.p.m. C.T.C.* | |
|---|---|---|---|---|---|---|---|---|---|
| | *Experiment No.* | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 30 days .. | Moisture (per cent) .. .. | 34·65 | 34·42 | 36·73 | 37·01 | 34·42 | 36·13 | 36·13 | 33·99 |
| | TVBN (mgm/cent) .. .. | 105·0 | 107·0 | 101·0 | 98·0 | 91·5 | 95·0 | 92·5 | 87·5 |
| | TMAN (mgm/cent) .. .. | 26·0 | 24·0 | 27·5 | 23·0 | 20·0 | 23·5 | 20·5 | 21·0 |
| | Org. Test Score (Max. 30) .. | 29·5 | 29·0 | 29·5 | 30·0 | 30·0 | 30·0 | 30·0 | 30·0 |
| 90 days | Moisture (per cent) .. .. | 35·60 | 34·38 | 36·56 | 36·49 | 34·60 | 34·53 | 36·01 | 34·03 |
| | TVBN (mgm/cent) .. .. | 180·5 | 178·5 | 177·0 | 179·5 | 171·5 | 167·0 | 117·5 | 103·5 |
| | TMAN (mgm/cent) .. .. | 66·5 | 64·0 | 62·5 | 57·5 | 50·0 | 53·5 | 39·5 | 37·0 |
| | Org. Test Score (Max. 30) .. | 24·0 | 25·0 | 28·0 | 27·0 | 27·0 | 26·0 | 28·0 | 29·0 |
| 120 days .. | Moisture (per cent) .. .. | 35·21 | 34·72 | 36·72 | 36·44 | 35·02 | 35·16 | 35·88 | 34·20 |
| | TVBN (mgm/cent) .. .. | 185·0 | 185·0 | 185·0 | 183·0 | 177·5 | 170·0 | 130·0 | 128·0 |
| | TMAN (mgm/cent) .. .. | 67·5 | 69·0 | 65·0 | 66·0 | 57·5 | 60·5 | 45·0 | 40·0 |
| | Org. Test Score (Max. 30) .. | 24·0 | 24·0 | 25·0 | 25·0 | 27·0 | 26·0 | 28·0 | 28·0 |
| 150 days .. | Moisture (per cent) .. .. | 34·26 | 34·40 | 36·57 | 36·59 | 34·81 | 35·01 | 35·81 | 34·35 |
| | TVBN (mgm/cent) .. .. | 222·0 | 205·0 | 213·0 | 207·5 | 196·0 | 186·0 | 153·0 | 155·5 |
| | TMAN (mgm cent) .. .. | 70·5 | 71·0 | 68·0 | 70·0 | 62·0 | 62·5 | 47·0 | 45·5 |
| | Org. Test Score (Max. 30) .. | 22·0 | 21·0 | 24·0 | 23·0 | 25·0 | 25·0 | 27·0 | 27·0 |
| 180 days .. | Moisture (per cent) .. .. | 34·69 | 34·64 | 36·38 | 36·61 | 35·02 | 34·96 | 35·78 | 34·43 |
| | TVBN (mgm/cent) .. .. | 317·0 | 343·0 | 320·0 | 315·5 | 281·0 | 277·5 | 210·0 | 206·0 |
| | TMAN (mgm/cent) .. .. | 75·5 | 83·0 | 80·0 | 85·0 | 70·5 | 74·0 | 56·0 | 60·0 |
| | Org. Test Score (Max. 30) .. | 19·0 | 19·0 | 21·0 | 21·0 | 22·0 | 21·0 | 23·0 | 24·0 |

# SOME ASPECTS OF THE STRUCTURE, LIFE HISTORY AND PHYSIOLOGY OF NAJAS GRAMINEA DEL., WITH NOTES AS ITS AUTECOLOGY

BY

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## Introduction

The paper deals with, a few aspects of the structure and life history of the plant *Najas graminea* Del., with special reference to the environmental conditions such as temperature, edaphic factors, etc. The plant is a common water weed throughout Madras State. It is especially predominant in the tanks and ponds of South Arcot and Tanjore district (e.g., Marakkanam, Veeranam lakes). The materials (*Najas graminea Del.*, and *Najas minor*) were available in plenty in Poongar Swamp near Bhavanisagar Dam. (Coimbatore district). The plant belongs to the family *Najadaceae* of monocotyledons. A very limited description is available for exomorphic and endormorphic characters and its habitat. (Manual of Acquatic plants Norman, C. Fassett 1940). Darlington has worked out the cytology of the plant and found it possesing ' X ' as 6 and totally 24 chromosomes.

The genus *Najas* is scattered throughout Madras State. Tle following are the number of species commonly available in the State:—

(1) *Najas indica*—Guindy Park-Madras.

(2) *Najas minor*—Nagari.

(3) *Najas indica*—Government Botonical gardens—Nilgiris.

(4) *Najas minor*-var-spinosa—Tanjore, Mathur village Guindy—Madras.

(5) *Najas graminea*—Marakkanam, Veeranam lakes, Agasthampatti, Thanjavur, Poonagar Swamp—Bhavanisagar.

## Systematic position of the plant

According to Gamble, *Najadaceae* is monogeneric family. The single genus Najas accomodates five species—

(1) *Najas graminea Del*—var—minor Rendle.

(2) ***Najas indica***—Chem.

(3) ***Najas major***—All var—spinosa.

(4) ***Najas** lacerata* Rendle.

(5) ***Najas** falciculata*.—A. Braun.

A. M. Johnson classifies Najadaceae as Naid (Najas, which includes ten species having Worldwide distribution in freshwater.) In the light of modern classification of Hutchinson the family Najadaceae accomodates two orders, namely, *Najadaceae* and *Zannichelliaceae*.

Following Engler A and Prantl. K. (1888), core includes forty species under Najas in his "*Plant Taxonomy*".

Hooker, J. D. (1909) reports 4 species, viz., *Najas major, Najas graminea, Najas minor* and *Najas falciculata*. According to him *Najas tenius*. *Najas beteromorpha* and *Najas rigida* are the three interminable species.

According to Hooker W.D. (1890) the family contains the following genera.—(1) Triglochin (2) Aponogeton (3) Ruppia (4) Najas (5) Zennichellia (6) Cymodacea (7) Potamogeton.

Mc Lean and Cook say Najadaceae is a monogeneric family containing 35 species of *Najas*. K. Subramaniyam classifies the representatives of Najadaceae according to the shape of the spathe and nature of partition in the antherlobes. The names *Najas* and *Naias* were found to be indentical and so are only synonyms.

## Nature of swamp

Removal of earth for the construction of the reservoir bundh from the part of the Poongar village caused a depression wherein the accumulation of seepage water from the reservoir converted it into an artificial swamp. Layers of lime stone are formed in certain regions along the northern margin of the swamp. The species selected for work is Najas *graminea Del.* At full swamp level, the length of the swamp is about 650 meters and the maximum breadth about 250 meters. The swamp slopes from its margin of about 4′ to a maximum depth of 9′ towards the centre.

## External Morphology of the plant

*Najas graminea* Del. F¹ Aegypte 282—

t. 50 ; f. 3 ; 1812 FBI 6 ; 569, 1893 Rendle in Pflanzeur, 7 ; 18 ; f. 5 Q. v ; 1901.

The plant ***Najas Graminea*** Del., is a slender, delicate bright and green acquatic plant. Roots develop at nodes. The plant branches dichotomously. The dichotomous division of the branches are prominent only in *Najas minor*. In *Najas gramineae* the branching is not so frequent. The densly leaved lateral branches and the tips of the main shoot results in a plumose habit of the plant. The average length of the mode of a healthy plant varies from 1·5 cm. to 2·25 cm. in the middle part of the plant, and 0·25 cm. to 0·5 cm. towards the tip. The nodes at the tip are so much aggregated that it is difficult to distinguish the individual nodes. The average length of a healthy plant leaf is about 2·5 cm. The plant flowers and fruits generally from July to August and from November to January after mansoon rains. The plant is both monoecious and dioecious. Separate male and female plants occur along with monoecious species. The plant is normally rooted, the length of the root varies from 16 cms. to 20 cms. when rooted in soil and between 12 cms. to 16 cms. when found floating. The plant when associated with *Chara* sp. is difficult to distinguish under submerged conditions.

*Leaf*.—Leaf margin is toothed variously. The nature of the marginal indentation in *Najas graminea* is clearly seen only while viewed under a dissection microsocope.

But in Najas minor (pres) All however the toothed nature of margin is visible even without microscopic examination. The leaves occur in pairs on the stem and an individual leaf possesses a sheath and a blade. The sheaths bear minute microscopic scales. In *Najas graminea*, the marginal teeth are each composed of only one cell. The teeth that are found in the lower level are broader and slightly shorter than the succeeding ones. The angle of the marginal tooth is always the same as that of the tip of the leaf itself. The length of the sheath varies from 0·35 cm. to 0·25 cm. The leaf at the point of attachment to stem is narrow and measures approximately 0·18 cm. to 0·25 cm. The bi-lobed sheath attaches the leaf with the stem. The breadth of the sheath is nearly 0·08 cm. It is also noted that the sheath of the upper leaves are embraced by the sheath of the lower leaves. Of the members of a pair of leaves, the position of one blade is a little more elevated than the other. The individual leaves are linear and needle like. There is a central thickened layer of cells making it a pseudomidrib. On each side of the midrib there is a zone of about 20 cells. The central midrib is composed of nearly 8 to 9 layer of cells placed one cell beside the other in a linear fashion.

*Roots.*—In most submerged plants, the roots are greatly reduced in size, unbranched and without root hairs. The underground stem is condensed. The exposed nodes develop the adventitious roots which are normally 3·5 cms. to 6·2 cms. long and 0·5 mm. in diameter. They may be longer than this and also thicker under specific environmental conditions. The roots are generally long, whitish and slender and anchor the plant when they come in contact with substratum. If however a fragment of the plant is unable to get hold of substratum, the root is elaborated in length without branching till it gets access to a hold. The course of the root is always negatively geotropic even in those fragments of plants producing such a long root. Those roots which are after a hold may become positively geotropic and again regain normal course. It was interesting to note in the experimental jars devoid of a soil substratum the long white roots in their vain bid to find a hold intertwine themselves. The plants that are rooted in soil develop minute hairs in the roots while those which are not rooted never develop such root-hairs. The roots examined from the specimens which are rooted present crooked appearance with small bends and curves while those of the floating fragments are smooth and straight without curve. The roots of a separated fragment though appear in slender are in reality very rigid. They are not easily softened even if kept in concentrated Acid used for making squash.

*Stem.*—Underground stem and aerial stem are found in the plant. The former is very much reduced and roots are developed in it. The aerial stem is soft and greenish. The ordinary length of the plant varies from 25 cm. to 50 cm. But in some exceptional cases specimens measuring 80 cms. to 100 cms. are also recorded from Poongar swamp. In the case of Najas minor Pers (All Fl. prfrn 2 : 221, 1785, F B.I. 6 : 569 1893 Rendle, 14f, Js. T. 1901 Fluviates minor pers syn 2 : 530, 1807, also available in Bhavanisagar) the branchings are prominently dichotamous. The stem is cylindrical, stiff coarse with nodes and internodes. Small needle like structures develop at the nodes from which the runners germinate. The stem of Najas minor is robust and profusely branched. The internodes are 18 mm. to 24 mm. long in the mature regions and 10 mm. to 5 mm. long in the growing apices.

### Anotomy (Native gramine Dael).

*Transverse section of stem:* (*Fig. No.* 1).—The transverse section of the stem shows the epidermis, ground tissue and vascular bundle or stele. A hallow is present in the centre of the section.

*Epidermis.*—The epidermal cells of the periphery are not cuticularised and so are able to absorb gases and nutrients directly from the water (John Weaver) (1938). The cells are thin and barrel-shaped with chlorophyll pigments.

*Ground tissue of Cortes.*—The hypodermal cells arranged in two or more layers occur beneath the epidermis. They are composed of thin walled parenchyma. The aerenchyma which are also thin walled connect the hypodermis with the Stele. The ground tissue is fissured into a number of air cavities by the parenchymatous cells that form a diaphragm between the hypodermis and stele. The aerenchyma is responsible for the boyancy of the plant.

*Central cylinder.*—The vascular cylinder is much reduced and endarch. In many plants such as *Najas* and *Elodea.* the fused xylem strands are reduced to a central thin cellular passage, which is surrounded by phloem. Here in Najas graminea the xylem is surrounded by phloem.

*Leaf.*—A transverse section of the leaf (Fig. No. 2) shows the following parts:—

*Epidermis.*—The outer layer is the epidermal layer with numerous disc-shaped chloroplasts in the cells.

*Mesophyll.*—Shows no differentiation into the spongy and the pallasade tissue.

*Central cylinder.*—In the young leaves vascular tissues are not differentiated. In the mature leaf even the vascular elements are thus very much reduced.

*Root* (*Transerverse section of Root*).—The adventitious roots and the roots developing from the condensed stems are identical in structure. A transverse section of an adventitious root (Fig. Nos. 3 and 4) shows the following parts :—

*Epidemics.*—Consisting of a single layer of closely arranged barrel shaped cells without the cuticle.

*Ground tissue.*—Consisting of many layers of more or less rounded cells with inter cellular spaces. The inner most layer of the ground tissue envelopes the central cylinder.

*Central cylinder.*—Najas has very simple root of a very simple type in which the phloem is more conspiciously developed than the xylem (Agnes Arbur 1920).

*Sex organs*—(*Male flower*).—Najas graminea Del, occurs both as monoecious and dioecious plants. If monoecious the male flowers are restricted to the tip of the plant and the female flowers to the lower portions of the plant.

The male flowers are strongly pink at the time of emergence which fades in a course of two weeks and ultimately to white. In other species of Najas besides the perianth an outer spathe also envelopes the flower whereas in Najas Graminea Del., such spathe is absent. The male flower is very simple in that the anthers are enclosed in a capsule formed by the closer approximation of the perianth. Hence the sporogenous tissue arises at the tip of the floral axis which develops from one to a four celled structure. The pollen grains of this species are oblong. They measure 10U to 30U in breadth and 30U to 75U in length. The number of pollen in a male flower is infinite and they come out of perianth in thousands as dusts when crushed under microscope. The ripe pollen grains are liberated through an apical dehiscence (Fig. No. 5) of the anthers. The dehiscence of the anther causes the liberation of pollen. Subsequently the perianth falls of. The growth of pollen tube from mature pollen grain is instantaneous which grows to about 100 U in ten minutes in a grain measuring 50U in length. No further growth is observed.

*The female flower.*—The female flower is also as simple and reduced as the male flower. The floral axis develops into an anatropous ovule from below as in the male and envelops the ovary. Thus a pair of integuments are formed. The Najas graminea the ovary terminates into a bifid stigma. The colour of the female flower at the time of formation is pink and turns successively to green, brown and ultimately dark. Such changes in colour appear to be indeces of different stages in maturity.

*Appearance and disappearance of dominance in sex of monoecious plants.*—In monoeciuos plants the occurrence of male and female sex were studied carefully. In the month of August and September the female sex was entirely dominant in monoecious plants. When examined on 11th September 1964, out of 151 plants 150 plants looked as though they were female. Only one plant was monoecious with large numbers of male flowers some strongly pinkish with well developed female flowers. The number of male flowers increased and almost equalled the female flowers by the end of October. In experimental cisterns during the last week of November the female flowers had attained the dark colour, thus indicating that they have already become ripe seeds. In the month of November the malesex was dominant.

*Germination of Najas graminea seeds.*—To germinate Najas graminea seeds in the laboratory and in fields, several experiments were conducted. First the seeds were allowed to germinate in petri-dishes with filter paper in it. Daily water was supplied to the seeds. Thus nearly forty seeds, were kept in four petri-dishes. Care was taken to note that the petri-dishes were always full with water. Similarly two petri-dishes of with soil from the Poongar swamp and another with the soil from one of the experimental cisterns were sowed with seeds and kept irrigated exactly as in the former. There was no sign of germination in the first two months. Only in the third month one seed germinated. The first seed took seventy-two days for germination in ordinary petri-dish with filter paper. Since the day of first germination from eight to twenty-five days four more seeds germinated. Thus altogether gernination of only five seeds took place out of forty. In the sample kept in the soil of the swamp only one germinated exactly on 112th day. It is evident that the seeds of Najas graminea are dormant for nearly three to four months.

The ripe seeds of Najas graminea is dark in colour with lots of ornamentation. It is hard and cannot be easily broken. The size of the seed varies from 1 mm to 1·5 mm. in length and about 1 mm. in breadth. Before germination the seed turns slightly brownish. The beginning of germination is marked first by the formation of the primordial root which is a white knot like structure. Approximately two days after the appearance of the root primordium a faint yellowish white structure measuring about 1·5 mm. identified as the primordial first pair of leaves emerge out of the seeds. Towards the third day elaboration of green pigment over the leaves is complete and elongation take places. The first pair of leaves encloses within it the next immediate pair. On the fourth day the second pair of leaves also emerge out. At this time one of the outer leaves measured 5 mm. and the other 3·5 mm. in length while the second pair of leaves though emerged was still unseparated. On the fifth day further growth in both the leaves and the root was noticed. The members of the first pair of leaves measured 6 mm. and 4 mm. respectively and those of the second pair were each 5 mm. long. The root by this time had grown to about 4·8 mm. in length and already penetrated the filter paper, helping the seedling to stand errect. In prostrate condition the growth of the root is from 20 to 25 mm. After 10 to 15 days of germination 6 or 7 nodes are formed in the plant and by this time another root develops from the second node. The first internode is comparatively longer and the second pair of leaves also much bigger than the preceding pair. The seedling when planted strikes root from the second pair of leaf.

*Growth.*—The growth of Najas graminea Del, is very slow during the first fortnight, after germination. The length of the plant at the end of the first fortnight, is only 2 to 3 cms. with six to seven nodes. The length of an one-month old plant varied from 3·5 cms. to 7 cms. since then the growth rate was comparatively faster, for (e.g.) one and a half month old Najas graminea varied in length from 15 cms. to 21 cms., just looking like adult plants. The seedlings that grew under laboratory conditions were straight without frequent branching. In field where there was intense sunlight and low water level the same batch of seedlings branched frequently. The internodes of the natural plants were smaller than those of the Laboratory plants.

*Development of sex organs.*—The sex organs made their appearance between 35th to 60th day. In the monoecious plants the female sex organs developed first. The female flowers were noted even on the 35th day as a pale green structure. Only after the 45th day it became pinkish colour. In between 35th day and 45th day male flowers were seen emerging at the upper part of the plant. The development of sex organs were noted both in field plants and laboratory plants simultaneously. In limited number of plants observed, those that grew under laboratory condition happened to be dioecious whereas those from the swamp and cisterns were monoecious.

*Pollination and seed formation.*—Pollination takes place under water and seed formation takes a long time. It varies from 60 to 75 days. Evenafter attaining the characteristic dark colour of a mature seed, the seeds do not fall so easily only when completely ripe the seeds fall down. The time thus taken for a seed to fall from the plant from the time of flowering may vary from 90 days to 120 days. However in the laboratory, plants studied in glass jars along with fishes, the frequent movement and disturbances caused by the latter made even some brown seeds to fall. The fallen brown seeds never attained the characteristic dark colour.

*Vegetative reproduction.*—It is very clear that during its life cycle Najas graminea reproduce largely by vegetative method. A fragment of a plant is capable of striking root and leading an independant life. In experimental cisterns and jars broken bits of the plants produced several adventitious roots from the older nodes to strike the soil and establish them. Several experiments were conducted to note the minimum number of leaves and length of plant required to reproduce vegetatively. An independant mature leaf if planted in soil does not produce new plant. Only bits of plants with atleast four leaves and an internode were found capable of sucessfully establishing a new plant. The longer the broken bit, the quicker it establishes itself as a new healthy plant.

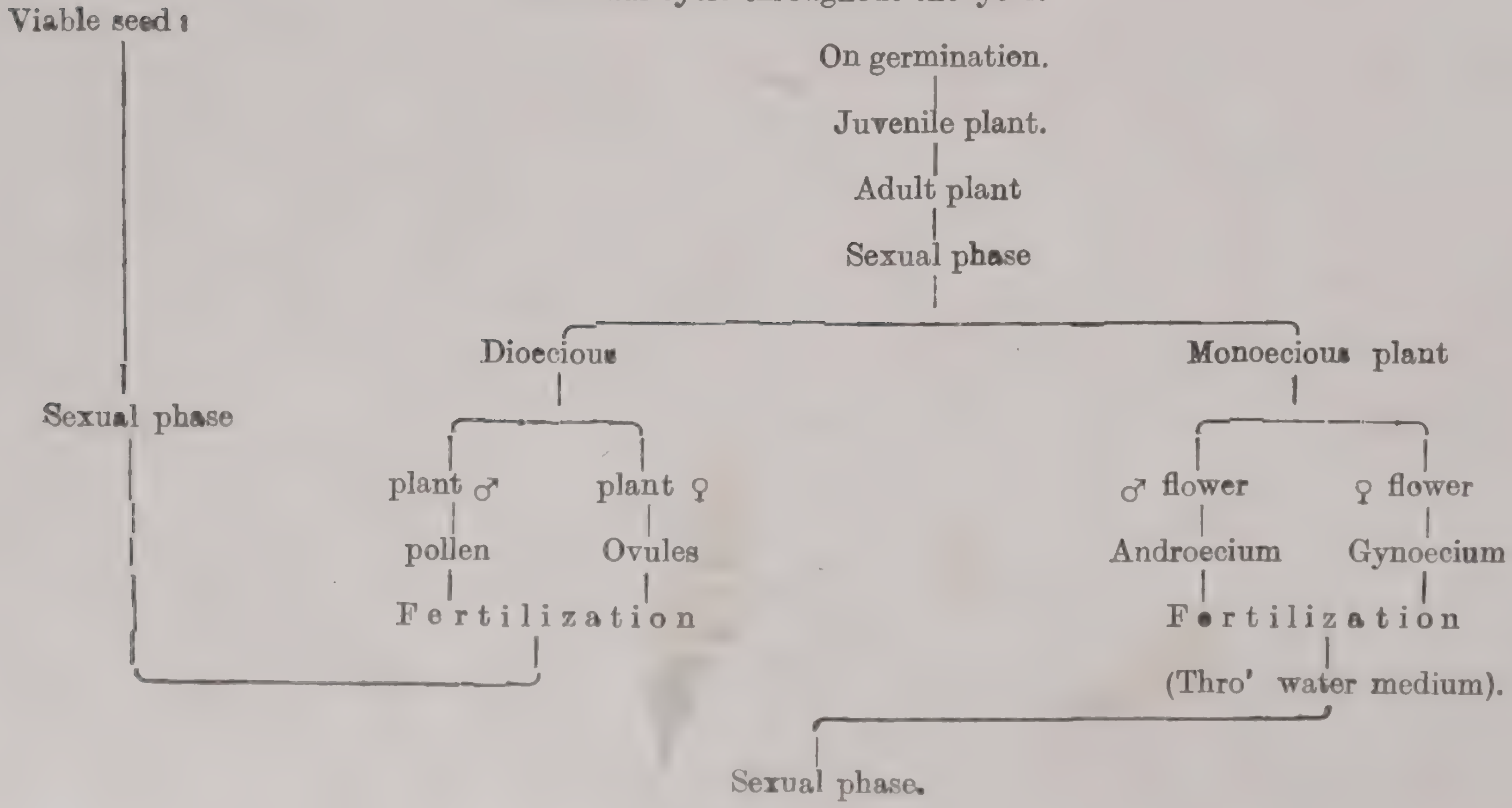
*Seed plants and vegetative plants.*—The difference in the growth rate of the seed plants and vegetative plants was not so striking. Bits of seed and vegetative plants were picked up from the experimental cistern. Equal length of material was selected from the tip of the plant in both cases. Individual leaves of both the plants were measured and compared. In this study nearly 4,000 leaves were examined. In each case it was noted that the leaves of the seed plants were on an average 0·523 cms. longer than those of the vegetative plants. The longest leaf of a seed plant measured 3·7 cm.

*Life history of Najas graminea Del.*—The plant Najas graminea germinates during October and November in ponds, puddles, etc., after monsoon rains in Madras State. The plants are restricted to the margins in big lakes and swamps where the depth varies from 3 feet to 5 feet. The plants grow also in the centre of small ponds and puddles of the depth of waterfalls to the above level. The plants growing at a depth of 5 feet grow luxuriantly with long internodes and measure nearly 4 feet to 5 feet. If the water level is in a dangerous condition leading to the possible death of plant; there is an attempt to flower ahead of ordinary plants occuring in optimum depths. Though the ordinary Najas graminea plant in field flowers between 40 to 60 days after its germination there is a general tendency to postpone formation of sex approximately a month which coincides with peak period of formation of flowers.

Simultaneous propagation both by seeds as well as by vegetative means is quite common. It becomes difficult at a certain stage to distinguish one from the other. The vegetative plants which got served from the mother plant also bore sex organs many times. But in general reproduction of Najas graminea under optimum conditions is mainly Vegetative. In ponds the number of floating fragments were amazingly high considering the number of plants that grew in them. The vegetative phase dominated the life history of Najas graminea beginning from November to March. By this time the seeds produced by the seed plants undergoing dormancy for about three months also develop into new plants.

*Life history of Najas graminea Del.*

Vegetative phase (A sexual reproduction).
Adult plant : Fragmentation.
A sexual cycle throughout the year.



The germination capacity of seeds is poor. Presence of germinating Najas graminea seeds along the river margin. (River Bhavani about a furlong below the Bhavanisagar Dam) during October and November suggests dispersal through river to ponds and puddles. However absence of adult plants in the river render the possible source of these seeds during monsoon rains which bring them from adjacent pools and swamps. The plant Najas is an annual aquatic herb. However, under optimum conditions the longivity is more. In the experimental cisterns where seasonal variations in the conditions of existence were not much pronounced, the plant grew normally for more than two years.

*Epiphytic algae in Najas graminea Del.*—Nearly eighteen numbers of algae were recorded in the leaves of Najas graminea. They are given below. They are sought out eagerly by fishes with browsing habit. (Cyprinus carpio strain Bangkok.).

*I. Chlorophyceae*—

1. Chlorococcum lummicoler Rab.
2. Closterium lunula (Muelli) Nitzsch.
3. Cosmarium subtumidum Nordst .
4. Oedogomium sp.
5. Crucigenia Morren apiculata (lemm) Schus.

*II. Cynophyceae*—

6. Oscillotoria limosa Ag. ex.Gomont.
7. O. Subbrevis schmid.
8. Nostoc carneum Ag. (Teitler).
9. Microcystis aeruginosa Kuetz.
10. Merismopedia tenuissima Lemm.
11. Anabaena orientalis dexin.
12. Nostoc punctiforme (Kutz) var popularum Geitler.
13. Phormidium ambiguum Gomont.
14. Schizothrix friesaii (Ag.) Com.
15. Rhaphidiospisis curvata Fritsch & Rich.

*III. Bacillariaphyceae*—

16. Cymbella hustedtie Krasske.
17. Navicula simplex Krasske.
18. Gomphonema apiculatum Ehr.
19. Pinnularia viridis (Nitz) ehr.

*General Ecology of the Poongar swamp.*—The swamp lies in the Poongar village facing the left flank of the reservoir bundh at an attitude of about 820 M.S.L. As has been pointed out earlier the swamp depends on the Bhavanisagar reservoir for its water. The supply is effected through seepage. The seepage water is led into the swamp through a small canal running horizontally at right angles to the bundh from the base of the left flank to the swamp. The bed level of the reservoir at the dam site is about 800′ M.S.L. and at full reservoir level it is about 920′ M.S.L. Table No. 1 shows the average rain fall and water level of the reservoir for each month (except July and August) of 1963 and 1964. The average rain fall given in the table pertains only to the local rains in Bhavanisagar. The catchment area of Bhavanisagar reservoir is the Nilgiris. The rivers Bhavani and Moyar draining through the catchment area bring in freshets during both South-West and North-East mansoon rains, into the reservoir. From the table it can be seen that in 1963 the South-West monsoon has failed, bringing down the reservoir level to 889·76′ M.S.L. Local rains in October, November and December of 24·47 mm., 5·74 mm. and 10·4 mm. respectively. North-east, did not have much effect and the level of December had come down to 870·58′ M.S.L. In 1964 by June the level had come down to 843·60′ M.S.L. These conditions adversely affected the swamp to almost a drought. It was reduced to a very small stretch of water of about 1/50th of the original area. These conditions prevailed for about two months and most of the hydrophytes collapsed. The flora encountered in order of dominance are as follows :—

*Chara gymnopitys, Najas graminea Del. Najas minor All, Typha angustata, Bory* and *Chact, Potamogeton indicus, Potamgeton pectinatus Linnes. Ottelia alsinoides Paspaldium punctatum stapf., Limnanthemum cristatum* and *Nymphaea stellata.*

The worst hit were the once profusely growing Najas, Potamogeton and Chara, Typha, being subjected to draught and frequent harvest by local people for making mats though managed to survive because of the underground rhizome. The North-east monsoon rains were timely and heavy as can be seen from the table. The water level by November 1964 was 917·93′ M.S.L. very close to the full reservoir level (920 feet M.S.L.). The swamp also was up to its brim.

It is evident that the water condition of the swamp directly depends mainly on that of the reservoir. It is interesting to see that since the reservoir and the connected fluvial systems do not have any of the hydrophytes present in the swamp, the probable agency which caused their access into it is still vague. According to Vernon W. Proctor 1962 " Oospores of several common North American species of Chara are able to survive a normal passage through the digestive tract of migratory water birds, and that many are dispersed in this manner.... ". That Oospores can be and frequently are carried by one body of water to another seems very probable. In one of his experiments 34 per cent of the spores of Chara Zylanica recovered from the gut of the Mallard duck (Anas platyrhynchos) germinated within two weeks. He considered from 40 per cent to 50 per cent germination normal for non-ingested Chara Zeylanica. A wide array of aquatic birds frequent these swamps. The most prominent in magnitude is an unidentified migratory bird which visits the swamp in February and March for making nests in Typha. Hundreds of nests with eggs and hatching birds are seen during this period. It is probable that such birds by periodically visiting may act as carriers of oospores and seeds of aquatic weeds. The fact that immediately after the filling up of the swamp all species of these water plants once subjected to severe draught bloom up readily must be mainly through seeds which generally keep a fresh even without water. Vegetative propagation may also supplement this to a certain extent.

Chara dominates all of these. According to Vernon W. Proctor (1962) in atleast some species of Chara prolonged dormancy require months before the germination of the Oospores. Even under severe drought both the dormant Oospores as well as the migratory birds appear to assure ready replenishment immediately after the filling up of the swamp. According to Norman C. Fassett, 1945 the Characeae mainly occur in hard water and often have incrustations of lime. In table No. 2 are given the free carbondioxide carbonate and bicarbonate values of the water besides temperature for each month of 1964 except July and August. There was no free carbondioxide. The bicarbonate increased from 418 P.P.M. in January to 687 P.P.M. in June Table I. This gradual increase in bicarbonate corresponded to the decrease in the water level of the swamp which was regulated by the water conditions of the reservoir (Table 2). The high bicarbonate content with decrease in the water level of the swamp is explained by the large scale death of Chara resulting in its non-utilisation. In September 1964, the bicarbonate was reduced to 115·3 P.P.M. and towards December it was only 50 P.P.M. This period coincides with the full level of swamp and the profuse growth of Chara. Cattails are the first invaders in a newly excavated pool (Norman C. Fassett 1940). Typha angustata might have been the first occupant when the swamp was newly formed in 1956 and 1957. In the course of a week or two of the filling up of the swamp the first vegetation to be seen in dense growth externally is Typha angustata. The extensive spreading up of underground stem can remain dormant markedly adopting the plant for survival once again when water is full.

Potamogeton pectinatus with narrowly linear leaves is submerged while Potamogeton indicus with eliptic Ovate leaves is floating. While the former is pre-dominant the latter is highly sporadic in this water piece. Both this species with special means of vegetative propagation are adapted to swamps of Poongar type. Potamogeton indicus grow from the rhizome of previous season and Potamogeton pectinatus forms tubers which appear to give rise to new plants in the succeeding season. (V. Singh-1964). In both cases propagation through seeds appear to play the dominant roll.

Limnanthemum Cristatum is available in this swamp only in the deepest portions (the original three wells which got submerged after the formation of the swamp) and also in the north-eastern margin by the side of the outlet. In the deeper portions other weeds are hardly present and in the vicinity of the outlet they are very sporadic. Eva mitra (1955) observed that new plants developing from floating rhisomes which get severred from the mother plant before attaching themselves to the soil, while deprived of the opportunity of coming into contact with the bottom mud, decayed within six days and sank to the bottom by about the 20th day. It is highly probable that the reason why Limnanthemum Cristatum is not found in the other areas of the swamp is be cause of the thick bed of Chara and Ottelia at the bottom. Najas and Potamogeton in the column afford very little chance for the new plants which accidently get detached by mechanical means to strike root easily and develop.

Najas graminea and Hydrilla verticillata overgrew to the extent of floating in nursery ponds and attracting a particular species of Trichoptera during August and September (Family Phryganeidae) which deposited their eggs over them. The larvae cuts stems and leaves and utilise them to make their cases. Hundreds of these larvae were found moving with their cases. It is interesting to note that the most common weed Hydrilla verticillata is totally absent though it grows in experimental cistern and in the slow-flowing canal supplying the Agricultural Research Station. Era Mitra observed this plant in some tanks of Calcutta inclose association with vallisinaria spiralis and Cerataphyllum demersum. In such cases the weeds were completely devastated in two weeks. During induced breeding of cyprinus carpio (Var.Bangkok) a weedy bed hydrilla or vallisnaria is commonly prepared inside the happa for the deposition of eggs. Najas can also be safely used for this purpose. It was found that grass carps preferred Hydrilla to Najas when both of them were present in the ponds. But when the former was absent they took to Najas sp. readily. A few specimens of Labeo fimbriatus examined from Veeranam lake (South Arcot district) had Najas in plenty in their guts. The acquatic herb-eating fishes of Bhavanisagar are Barbus carnaticus and very occasionally Barbus hexogonolepsis. But they are absent in the swamps and as such have no control over the growth of Najas.

### *Summary.*

1. Morphology of the plant is described.
2. Anatomy of the plant is worked and described.
3. Dominance of sex in monoecious plant in different periods of life history is described.
4. Life history of the plant is worked.
5. General ecology of Poongar swamp with Najas graminea is desecribed.

### *Acknowledgment.*

The authors are much indebted to Sri A. Sreenivasan, Assistant Director of Fisheries (Hydrology) for suggestion of this problem, his guidance and interest at every step of this investigation and constructive criticism. Suggestion and help from colleagues, Messrs. M. Devaraj, V. Natarajan, and assistance in soil and water analysis by R. Soundararajan is gratefully acknowledged.

### TABLE No. I.

| *Months.* | *Average rainfall,* 1963. | *Average rainfall,* 1964. | *Humidity,* 1963. | *Humidity,* 1964. | *Average water level of the reservoir.* | |
|---|---|---|---|---|---|---|
| | | | | | 1963. | 1964. |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | (MILLE METRE) | | (PER CENT.) | | | |
| January .. .. .. | 0·49 | .. | 73·9 | 79·3 | 913·28 | 877·15 |
| February .. .. .. | 0·26 | .. | 73·7 | 79·4 | 907·39 | 867·96 |
| March .. .. .. | 2·90 | 0·77 | 77·9 | 85·1 | 903·29 | 855·26 |
| April .. .. .. | 2·11 | 1·01 | 77·2 | 75·6 | 897·22 | 846·91 |
| May .. .. .. | 4·08 | 10·7 | 70·9 | 69·9 | 900·82 | 847·73 |
| June .. .. .. | .. | 0·77 | 68·7 | 68·3 | 900·43 | 843·60 |
| July .. .. .. | .. | .. | 79·4 | 79·1 | .. | .. |
| August .. .. .. | .. | .. | 77·7 | 81·3 | .. | .. |
| September .. .. | 3·19 | 3·21 | 73·6 | 67·6 | 889·76 | 914·61 |
| October .. .. .. | 24·47 | 77·7 | 82·4 | 77·2 | 881·24 | 912·74 |
| November .. .. | 5·74 | 13·3 | 85·2 | 77·4 | 880·80 | 917·93 |
| December .. .. .. | 10·4 | .. | 87·4 | 66·29 | 870·58 | 916·29 |

### TABLE No. II.

*Water Analysis* 1964 *at Poongar swamp.*

| *Months.* | *Temperature.* | *Free $Co_2$ ppm.* | *$Co_3$ ppm.* | *$H\ Co_3$ ppm.* |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| January .. .. | 26·0 | .. | 29·00 | 418·00 |
| February .. .. | 30·2 | .. | 15·00 | 485·00 |
| March .. .. .. | 30·0 | .. | 14·00 | 492·00 |
| April .. .. .. | 32·0 | .. | 20·00 | 590·00 |
| May .. .. .. | 32·0 | .. | 40·00 | 665·0 |
| June .. .. .. | 30·0 | .. | 54·00 | 687·00 |
| July .. .. .. | .. | .. | .. | .. |
| August .. .. .. | .. | .. | .. | .. |
| September .. .. | 28·5 | .. | 21·0 | 115·3 |
| October .. .. .. | 28·5 | .. | 22·0 | 116·7 |
| November .. .. | .. | .. | .. | .. |
| December .. .. | 29·8 | .. | 55·0 | 55·0 |

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## Najas. graminea Del., (Stamen or Androecium)

Fig. No. 5 Front View (i)

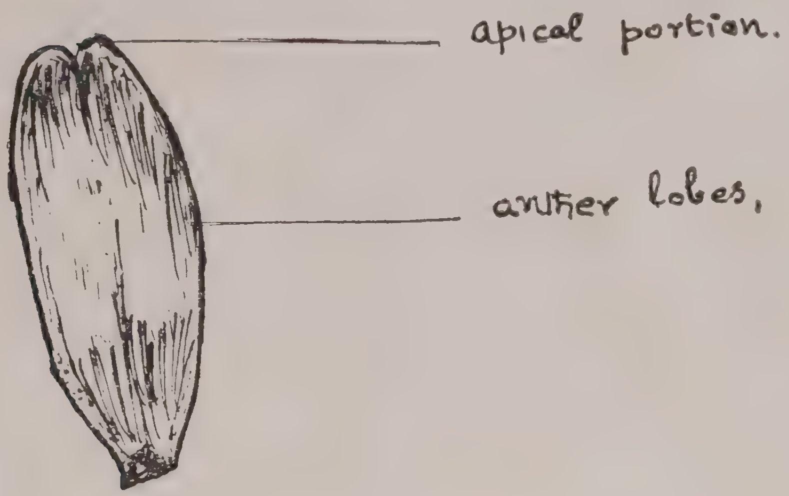


Fig. No. 6 Side View of Stamen. (ii)

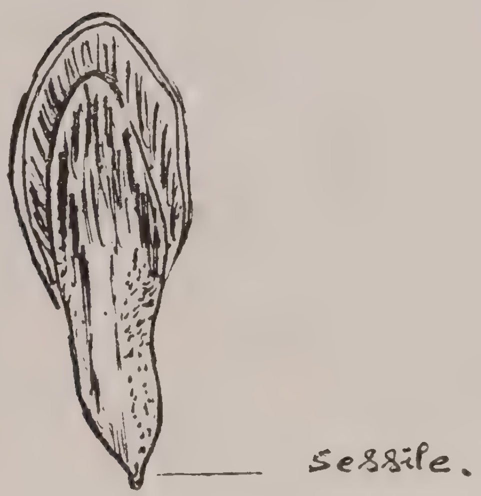
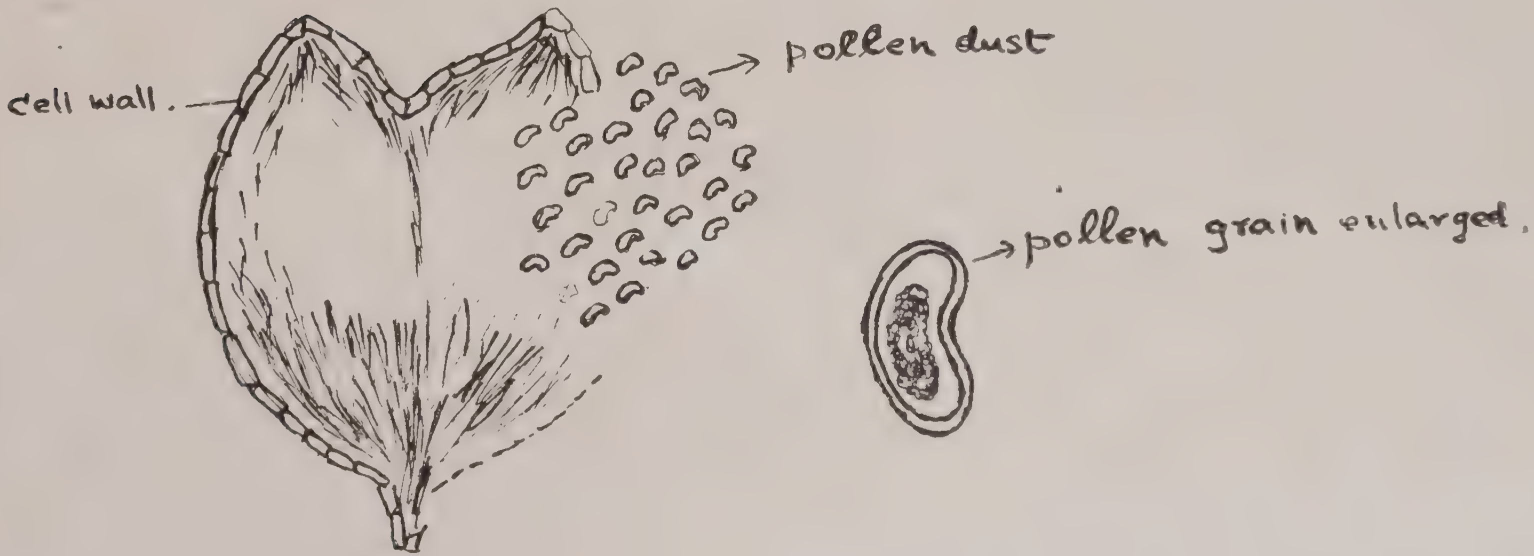
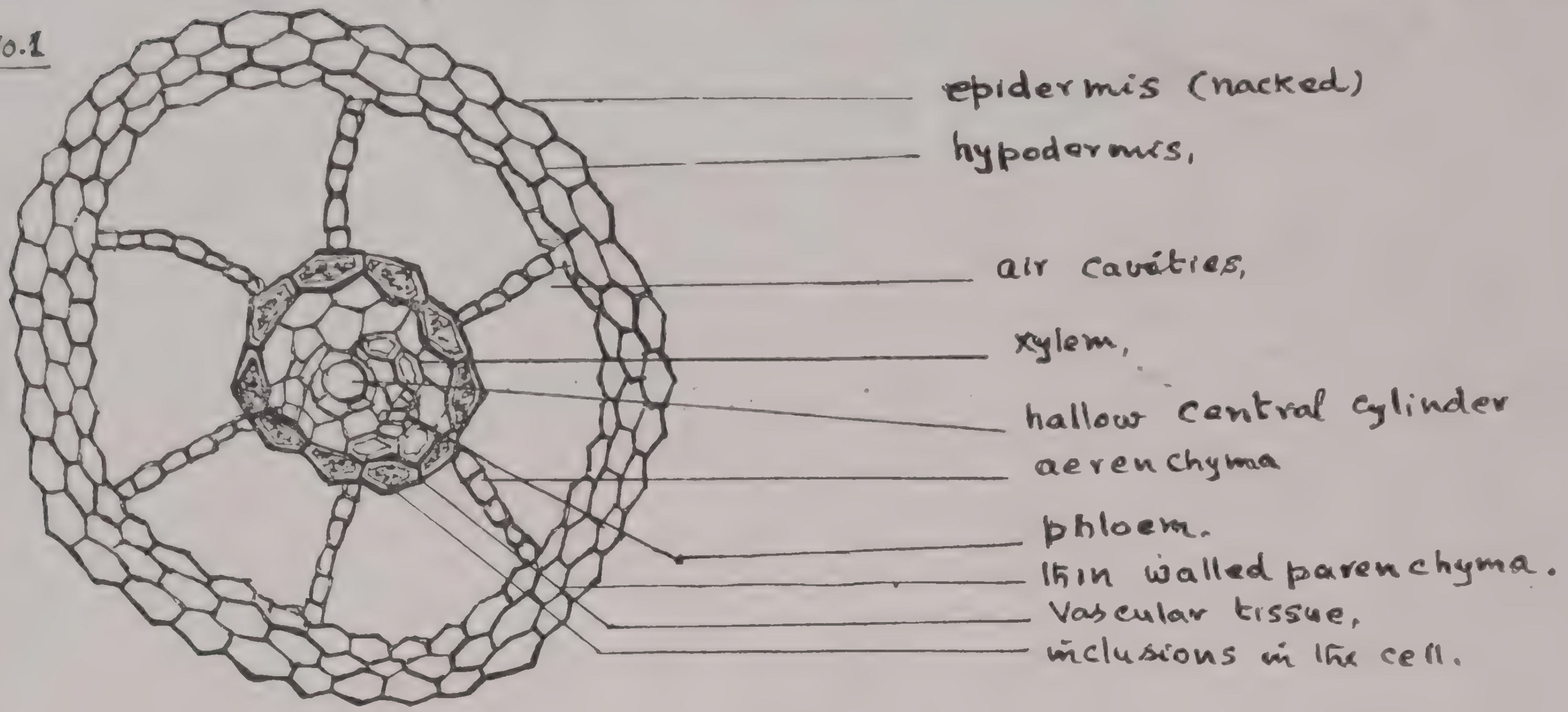


Fig. No. 7 Crushed anther



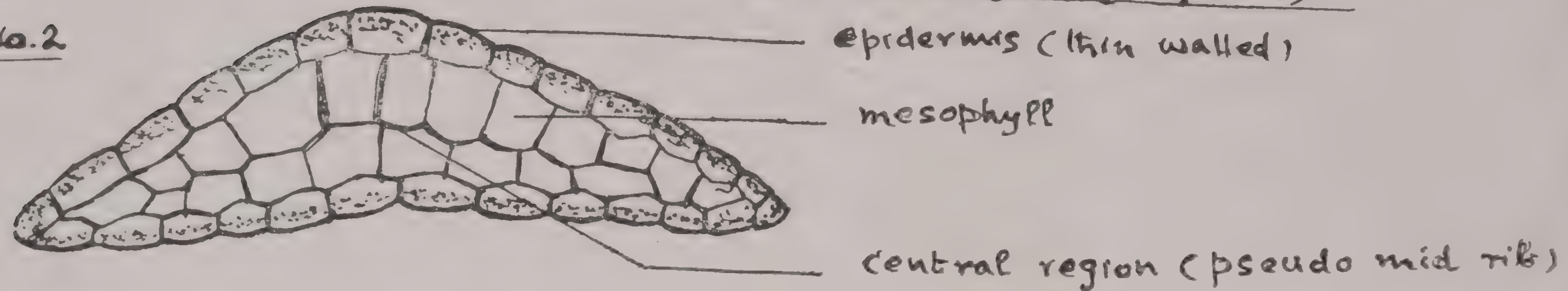
## Najas graminea Del., Transverse Section of the Stem.

Fig, No.1



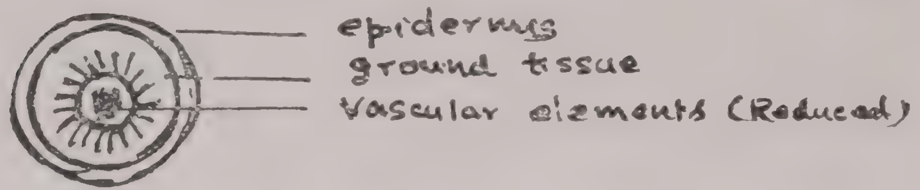
## Cross Section of the Leaf (High power)

Fig. No.2



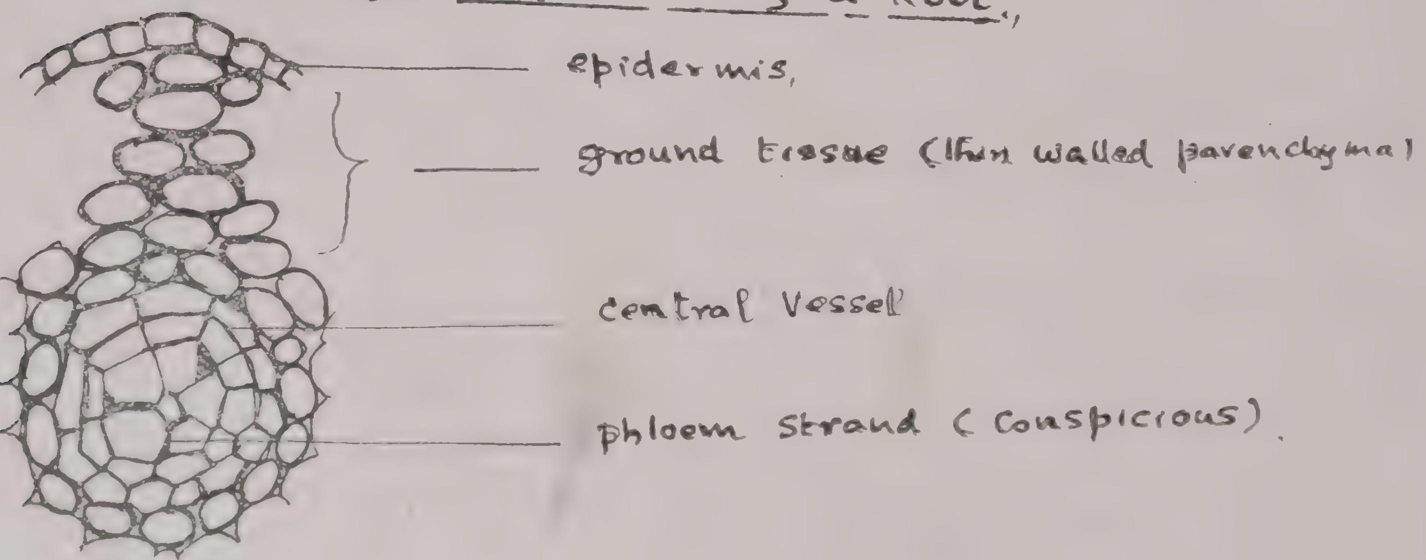
## Transverse section of Root

Fig. No.3.



## To enlarge a portion of a Root,

Fig. No.4.


epidermis,
ground tissue (thin walled parenchyma)
central vessel
phloem strand (conspicious)

# TILAPIA MOSSAMBICA : ITS ECOLOGY AND STATUS IN MADRAS STATE, INDIA

BY

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*Tilapia mossambica*, Peters, the cichlid fish, made a controversial entry into Madras and remains a controversial fish throughout the world. Chacko and Devadas (1953) claimed they were the first to bring the fish from Ceylon to Madras but Panikkar and Tampi (1954) had imported them earlier from Bangkok for experimental work at the Central Marine Fisheries Institute at Mandapam. At a time when fish culturists all the world over were after a fish that would be of immense use in increasing the protein output by maximal production, *Tilapia mossambica* came into the picture from obscurity. It raised very high hopes as seen from the assertion of Kelly (1957)—" The quest of fishery workers of various countries for a fish of fast growth rate, large reproductive capabilities, and a palatableness suitable for wide human consumption has apparently been satisfied to a great extent by this fish". The Government of India was cautious in the introduction of this fish and restricted its spread initially to areas South of Vaigai River (Madurai district) and excluded its spreading in the great rivers of the north where carp culture was important and lucrative. The State Government of Madras, through its Fisheries department introduced this fish with great hopes and spread it through the length and breadth of the State, even north of Vaigai river. Here a review is made and the position of *Tilapia mossambica*, in Madras State for the past ten years. It is not proposed to review the earlier literature on the subject since the review of Chimitz (1955) (1957) has already furnished an excellent bibilography. The experience of the Madras State Fisheries department in the culture of *Tilapia* in various types of waters is presented here, along with brief notes on the hydrobiological conditions of these waters.

## Historical

Though the Central Marine Fisheries Institute, first brought *Tilapia mossambica* to India for experimental purposes, the State Fisheries department of Madras were the first to introduce the fish for commercial culture. The results of research done on the food and association of *Tilapia mossambica* in Madras, have been published (Menon and Murthi, 1956) and Menon *et al* (1959). The observations were made in a controlled fish farm at Chetput and a polluted body of water in Thanjavur. These observations were of a short-term nature.

## Status of Tilapia in Madras Ponds

Almost all the ponds maintained by the State Fisheries department have been stocked with *Tilapia mossambica* along with Carps and *Chanos chanos*. Based on a study of these ponds for over eight years, it was found that it is difficult to classify waters as " Tilapia water " and " non-Tilapia water ", on the basis of hydrobiological factors. Hence we have arbitrarily divided these waters into three categories based only on the average size of *Tilapia mossambica* obtained from these ponds—

(1) ponds yielding very small sized *Tilapia*, smaller than 100 g. each.

(2) ponds yielding medium sized marketable *Tilapia* 100 to 300 g. and

(3) ponds or other waters yielding *Tilapia* of weight 300 g and over.

(1) *Ponds yielding small Tilapia.*—In Table I, the name and the hydrological conditions of ponds belonging to this category is furnished. The temperature of surface water in these ponds varies from 27·4 to 32·0°C the pH value from 7·5 to 9·6 the methyl orange alkalinity (expressed as $HCO_3$) 71·0 to 292·8 the chloride content from 48 to 536, the hardness from 60 to 274, calcium 47 ro 86·2 mg/l and the electrical conductivity from 380 to 2,125 micromho. The dissolved oxygen varied from zero to 23·0 mg/l but mostly it ranged from 0·5 to 5·0 mg/l. It is thus seen that small sized *Tilapia* are produced under wide hydrological conditions. The pH value of all the waters is on the alkaline side but mostly it is below 8·5. The temperature is fairly high. The methyl orange alkalinity is generally high, so also the electrical conductivity with a few exceptions, the water was hard. The low oxygen content of these waters is striking. Over-crowding by myriads of small sized *Tilapia* (respiration of small fishes is higher than that of larger ones) could be an important factor in the depletion of oxygen. Resistance to low oxygen tension by small *Tilapia* has been noted by us on many occasions.

(2) *Ponds yielding medium sized Tilapis.*—The surface temperature of the water of these ponds is not different from the ponds in Category (I). The range of temperature is 27·2 to 32·0. The pH value of these ponds ranged from 7·2 to 9·6 : the methyl orange alkalinity ranged from 45·8 to 552·5 (as $HCO_3$) but in general it was between 150 to 200 mg/l. The Chloride content varied from 16·0 to 536 but the majority of the ponds were in the range 60 to 250 mg/l. The calcium content ranged from 3·1 to 98·6 and the hardness from 60 to 274·0. The conductivity of the water of these ponds ranged from 375 to 2,650 micromho. The dissolved oxygen of these ponds is generally adequate but in a few cases very low or absent.

(3) *Waters yielding large-sized Tilapia.*—The surface temperature of these waters is generally lower than those of the two previous categories of waters, exceptions being small ponds. Most of the waters in this group are large pieces of wild waters such as irrigation tanks (minor reservoirs) and large impoundments (major reservoir ). The pH value of the waters ranges from a low value of 6·5 in an upland lake (Yercaud) to a high value of 9·5 in

some eutrophic ponds. The methyl orange alkalinity of this group is in many cases lower than that of the previous group, so also the electrical conductivity. The chloride content, hardness and calcium content also were lower.

It is seen that ponds in which small sized *Tilapia* dominate are small and less than 4·0 acres but with a depth comparatively greater than the ponds of group (II). Ponds in the latter group have a greater area than those of group (I) though a few are small also. Only in the larger pieces of water in group (III) we find *Tilapia* also of larger sizes. In wild waters, *Tilapia* grows to a larger size than it does in small artificial ponds. Spatial factors, thus seem to influence the size of *Tilapia*. Kenny (1960) noted that " in small over crowded ponds fish (*Tilapia*) matured and produced off spring in three months ".

Majority of ponds in group (I) have very heavy blooms of algae. In these tanks, undigested algae as faecal pelletes of *Tilapia* were a common sight. Hickling (1961) and Fish (1951, 1955) had in fact found that some species of *Tilapia* do not digest blue green algae. However it is possible that this partially digested material can act either as manure for the pond or as food for other fishes. It is known that ammonia produced metabolically in ponds over-populated by fish has a depressing effect on growth (Kawamoto, 1959). Menon *et al* (1959) admit that " if *Tilapia* is left uncropped or un-controlled, a certain amount of population pressure sets in creating conditions of such alarming nature as smaller and still smaller generation succeeding one another ".

### Mutual inter-action of Tilapia mossambica with other species.

There are conflicting findings on the effect of *Tilapia* on other species such as carps in the same eco-system.

In the ponds of Chingleput district with heavy blooms of algae in which *Chanos* were stocked along with *Tilapia*, the recovery of *Chanos* was negligible and the growth was very poor. The exploitable size of *Chanos* in these ponds, viz., Thimmarajakulam, Veppunkulam, Karpoorachettikulam, Rangaswamykulam, etc., since 1958 was less than 100·0 g. though in such waters resembling temple tanks (Ganapathi, 1940) the growth of *Chanos* should be atleast 500·0 g. per year. In Karpoorachettikulam *Chanos* was attaining size of nearly 1·0 kg up to August 1956, but subsequently, on the introduction of *Tilapia* the average size was 45 g. and the largest Chanos was not more than 100 g. The weight of *Tilapia* in the first six months after introduction was about 200·0 g. but subsequently the average weight of these went down to less than 45·0 g. Prior to stocking with *Tilapia* the weight of *Chanos* caught in these ponds was as much as 900·0 g. each. In Veppankulam pond, the average weight of *Tilapia* was 135·0 in 1958–59 and 1959–60, 100·0 g during 1960–61 and was less than 75·0 g. in 1961–62. Uncontrolled breeding is the cause. In this pond, *Etroplus suratensis* another chchlid fish failed to show up in catches after the introduction of *Tilapia*. In Chettikulam from which Chacko and Ganapathi (1950) reported phenomenal growth of *Catla catla*, *Tilapia* of average size 250·0—330·0 g. were exploited in 1958–59 but the average size of *Chanos* went down to 100·0 g. The average size of *Tilapia* also dwindled to 80·0 g. This pond, because of good phyto-plankton bloom including the presence of filamentous algae was best suited for *Chanos*. More than 50 per cent of the Catches of this pond are *Tilapia*. In Sarvatheertham, a temple pond, the size of *Chanos* was 800·0 g but after the introduction of *Tilapia* the size of *Chanos* went down to 65·0 g. *Tilapia* first introduced in May 1958, bred in August, same year. In Vellore Fort Moat the average weight of *Tilapia* was 240—310 g. in 1957–58, but in 1959–60, it had dwindled to 170—270·0 g. In Poondi fish farm ponds where *Tilapia* were grown *Notopterus notopterus* the size of the former was 26·2—26·8 cms. (206 to 280·0 g.) in 1958. In five months the growth was 50·0 to 100·0 g. In Vellaikulam pond, Arni, the size of *Tilapia* exploited ranged from 38 to 90·0 g. but growth of *Catla* was very poor—230·0 g. The Quarry pools of Virudhunagar were once a good biotope for the culture of *Chanos* and carps since they resembled temple tanks. But in Quarry Pool 2, which was shallow the catches were mainly small sized *Tilapia*. In the deeper Pool 3, *Chanos* grow to 1 lb. and *Catla* to 16—20 lb. each though *Tilapia* were also present. (This was a large pond 6·6 acres in extent.) In the two departmental ponds in Karunguzhi small-sized *Tilapia* were the main fishery. In the departmental pond, Valaiveesiteppam in Madurai town a small half acre pond with dense algal bloom only small sized *Tilapia* were available in plenty, the stocked *Chanos* not showing up in catches. In Ayyankulam, Thanjavur, in which *Chanos* was thriving well, growth of this fish declined after stocking with *Tilapia*. Even the growth of major carps such as *Catla catla*, *Labeo fimbriatus* and *Cirrhina mrigala* was adversely affected. *Tilapia* itself had shown good growth the average size being (25–28 cms.) 340·0 g during 1957–58 but subsequently the size dwindled. The K. factor was 1·4—1·6 in 1957–58. In the Fort Moat pond at Arni, *Tilapia* stocking has adversely affected the growth of *Chanos*. The growth of *Catla catla*, *Labeo* sp. and *Cirrhina* was also poor. *Tilapia* of sizes 16·5 cms. to 20·5 cms. and weight 75·0—155·0 g. were exploited in this pond. In Teppakulam, Sivaganga, a typical temple pond with a permanent bloom of *Microcystis aeruginosa* the average size of *Tilapia* was 100·0—110·0 g. but that of *Chanos* was less than 200·0 g. though this should grow to at least 500·0 g in a year. In the Anjaneyarkulam in Villupuram, a very productive water, the average exploited size of *Tilapia* was 80·0—160·0 g. but the size of *Chanos*, was only less than 225·0 g. In Theerthankulam, Tindivanam, the stocked *Tilapia* has so increased in population that its average exploited size gradually came down from 160·0 to 50·0 g. *Catla* which was growing fast in this pond, prior to the introduction of *Tilapia* is showing poor growth —270·0 g. in a year and the growth of *Chanos* is also poor 225·0—260·0 g. each. Kalukatti tank in Karaikudi is another glaring example of a pond rich in plankton (0·6 c.c./1) showing poor results after *Tilapia* stocking. Though initially higher yield of *Tilapia* was obtained, year by year the size of *Tilapia* went down till the average weight was less than 30·0 g. The largest sized *Tilapia* from this pond weighed only 60·0 g. This pond not only showed very bad growth and survival of *Chanos* but even the growth of *Catla* and *Labeo* and *Cirrhina* sp. was drastically reduced. Mariamman teppam in Madurai is a standing example of the failure of *Tilapia* in sustaining the yield of fish. This is a very productive pond, abounding in plankton. This was one of the demonstrating ponds for the culture of *Chanos*, which was showing good returns, the growth reaching at least 450·0 g. a year. But as a result of stocking *Tilapia*, growth and survival of *Chanos* was badly affected. *Tilapia* multiplied so profusely that one could collect a glass of water from this pond and get thousands of *Tilapia* fry. Even major carps were badly affected. In the sewage fish farm ponds in Madurai, *Tilapia* continuously multiplied and got overcrowded with size not more than 22·0 cms. (100·0 g. maximum). *Chanos* hardly grew well in this water with very heavy blooms of phytoplankton, their size remaining 2·2 cms. (28·0 g.). The balance of evidence clearly shows that introduction of *Tilapia* has positively ruined *Chanos* culture and has in many cases decisively affected carp-culture. In Bhavanisagar fish farm breeders of *Cyprinus carpio* of weights above 1·0 kg. were stocked after draining the pond, clearing *Tilapia* and refilling. But *Tilapia* which entered through inlet waters multiplied soon and it was seen that the food was attacked by the myriads of small *Tilapia* and the carps rarely approached it, resulting in their impoverished growth. Thus even small-sized *Tilapia* could affect the larger sized fishes. In a temple pond in Coimbatore town, the mirror carp *Cy. carpio* were introduced in September 1956, where within a few months they grew to 500·0 g. each and in a year they had increased in weight to 1000·0—1200·0 g. But, unwisely *Tilapia* were introduced during 1958 resulting in their uncontrolled multiplication. In June 1961, *C. carpio* 250 numbers were stocked at a size of 25·0 g. average size. After 13 months they were still 125·0—175·0 g. each and after 23 months they were of the same size though they attained maturity. *Tilapia* were all less than 60·0 g. each in a temple pond in Avanashi, the mirror carp *Cyprinus carpio* had grown to 400·0 g. in four months but subsequently growth was arrested by *Tilapia*. Growth of *Chanos* was very poor. Yashouv (1958) noted in Israel that in mixed cultivation with carp, *Tilapia mossambica* disturbs the development of carp.

Tilapia in relation to predators, is, however, controlled. In all the departmental ponds studied, it was noted that wherever predatory species such as murrels (*Channa marulius, C. striatus*, etc.) the gobie (*Glossogobius giurius*), the fresh water shark (*Wallagonia attu*) the feather back (*Notopterus notopterus*) were present, the uncontrolled breeding of *Tilapia* was checked and the size of *Tilapia* improved. In some of the ponds predators entered naturally and in some others they were deliberately introduced to control *Tilapia*. Menon *et al* (1959) have clearly established that better growth of *Tilapia* occurs when a predator like murrel was present in the pond. They also cite examples to show that in the presence of predators like *Notopterus notopterus*, *Sacchobranchus fossilis* and *Glassogobius giuris*, *Tilapia* was found to grow better. Hickling (1963) indicates that stocking with predators and population control will give larger sizes and yields.

In Webster Moat, Tanjore, which is the most productive pond in this State (Sreenivasan, 1962) some predators such as murrels (the snake head) were present. Due to the presence of some deep pits in this shallow pond, they escaped capture but they kept down the populations of *Tilapia*. Initially, during the earlier years 1956–57, the average weight of *Tilapia* was 540·0 g. but subsequently this declined to 280·0 g. But generally the weight range was stabilised at 120·0 g. to 330·0 g. (18·0—29·0 cms.). In this pond, carp culture was not affected and species such as *Catla, Rohu, mrigal, Cirrhina cirrhosa, Labeo* sp. thrived and grew well to large sizes. In the West Moat pond in Tanjore, *Wallago* were present—even those of weight 10·0 kg. In this pond also generally *Tilapia* were above 100·0 g. in weight, ranging from 112·0 to 238·0 g. Here too carp culture was not affected by *Tilapia*. *Rohu–mrigal* and *Catla* were raised as breeders from this pond. It was in Sengulam pond, Mannargudi that best growth of *Tilapia* was noted. During 1957–58 the average weight of exploited *Tilapia* was over 400·0 g. (34·5—38·5 cms.). Presently *Tilapia* of sizes 150·0—325·0 g. (18·0—26·0 cms.) are being caught. In this pond also carps have fared well and their growth had been good. In Ayyangulam Pond, *Tilapia* of sizes 25·0 to 29·0 cms. (330·0 to 400·0 g.) were common during 1957–58 but now the size has decreased.

Though ponds in Chingleput district have been the haven of small sized *Tilapia* an exception is the Fort Moat pond of 7·0 acres in which the murrels thrive. In this pond, plankton did not occur as a permanent bloom but only as seasonal bloom. The water is disturbed by continuous inflow and outflow. The average size of *Tilapia* exploited is 31·32 cms. (500·0—550·0 g.). *Catla, Rohu, Mrigal* the major carps grow well in this pond and this is used as a breeder pond for them. "Manthai Oorani" pond in Vadugapatti (Madurai district) was also one of the ponds where *Tilapia* population was restricted and the size was over 200·0 g. each. In North Arcot district in the following ponds, controlled population of *Tilapia* yielded exploitable sizes over 100·0 g. each—in Ayyankulam (Tiruvannamalai) murrels were present and there was continuous disturbance of the water by people bathing and washing clothes in all areas of the pond, the depth of which was 3·8 m. The dominant bloom of this pond was of *Cyanophyceae*. The exploited size of *Tilapia* was 20—23·5 cms. (175·0—225·0 g.) growth of carps—*Catla, Mrigal Cy. carpio, etc.*, were good and *Chanos* also grew well. In Ellaipillayarkoil pond also presence of murrels kept down the numbers of *Tilapia* 75—115·0 sizes taken. In Samedankulam pond, Cheyyar, the exploited size of *Tilapia* ranged from 15—21·5 cms. (125—170·0 g.). Breeding was restricted, since the bottom was firm. In the departmental pond in Chengam, where murrels and gobies were present, *Tilapia* were of size 19—24 cms. (125—145 g.). In Vellore Fort Moat pond, a deep polluted water with heavy bloom of *Microcystis* and where predatory species such as *murrels, gobies notopterus* and *Sacchobranchus* were present, *Tilapia* had never been a pest. In Teppakulam pond, Kulithalai, where the murrels exist and breed the average size of *Tilapia* is over 500·0 g. though a few are 250·0 g. also. *Catla* grows well in this pond which has no ostensible bloom of algae but has submerged and emergent weeds and periphyton. In Tirumakulam, Madurai, also *Tilapia* exploited are of large size 21—26 cms. (200·0—325·0 g.), in contrast to Mariamman Teppam in the same city. In Sivaganga teppakulam pond, *Murrels, Tilapia, Catla Chanos* and *Labeo* spp. were introduced. This typical temple pond has a dense bloom of algae and mollusca. *Catla* grows well (2·5 kg.) but *Chanos* was only of size 200 g. *Tilapia* were controlled and their average weight was 110·0 g. A very striking example of the role of predators in the control of murrel was seen in Chakkadi Oorani in Sivaganga. This was a shallow pond with good zooplankton population. *Tilapia* and murrels alone were stocked. The size of *Tilapia* was 150—220·0 g. and the yield of *murrels* was very high. However, the largest sized *Tilapia* obtained from small ponds was from Saravana Poigai, a pond in Valliyoor (Tirunelveli district), a typical temple pond. Here the normal size of *Tilapia* were 27—35 cms. (320·0—680·0 g.) more often 650·0—680·0 g. It is inexplicable that another pond just 20 m. away from this, yields *Tilapia* of size 100·0—200·0 g. only.

### Tilapia at high elevations

At higher elevations, due to lower temperature, breeding of *Tilapia* has not been profuse. In the Shevroy Hills (elevation 1,500 m.) temperature ranging from 20—26°C, *Tilapia* was first introduced in Yercaud lake in September 1957 bred within five months (in February 1958). This lake has a permanent but mild bloom of blue green algae. The *Tilapia* grew well, the average exploited size always being over 300·0 g. and mostly about 450·0 g. *Tilapia* of sizes 750·0 g. are also sometimes recorded. At the same elevation *Tilapia* were introduced in the Cauvery Peak Estate ponds where they were grown in monospecies culture. Here also they attained large size of 300·0—700·0 g. average weight but never got over populated. In the Mohanad pond which had an over growth of *Najas*, large *Tilapia* of sizes 1·0 to 1·2 kg. were common. *Ophiocephalus punctatus* were also present. Temperature was 26·6°C. Perhaps the lower temperature regulated precocious spawning. This is confirmed by Criddland (1962) in laboratory experiment. Kemp (1960) recorded a growth of 168·0 g (23·0 cms.) for *Tilapia* in five months in a pond at an elevation of 1,600 m. in New Guinea. In Kodaikanal lake (elevation about 2,400 m.), *Tilapia* were introduced into two small ponds. The temperature here did not exceed 22·0°C. and was about 16·0°C *Tilapia* did not grow and did not also multiply under these conditions. It failed to survive in waters in Ooty (elevation 2,500m.).

### Tilapia in Reservoirs

In rivers and large reservoirs, *Tilapia* has not posed any serious problem. Because of fluctuating water levels the breeding " pits " of *Tilapia* are affected. Further, being a slow growing species, predators make a meal of them. In most of these waters, *notopterus*, *Wallago*, *eels* and Cat fishes are present and they check the multiplication of *Tilapia*. Heavy stocking with *Tilapia* has been made in Vaigai, Sathanur, Amaravathy, Krishnagiri and Manimuthar Reservoirs. In Vaigai Reservoir, *Tilapia* forms a major fishery in the gillnet catches and by numbers constituted about 40 per cent of the catches during 1961–62, and 1962–63. By weight 25—50 per cent of the catches were *Tilapia*. The associates were the indegenous *Labeo contius*, *Barbus* spp. *Eels*, *Callichrous* sp, *murrels*, Cat fishes, *Wallago* and the introduced *Catla*, *Labeo fimbriatus*, *Cyprinus carpio*, etc. Plenty of *Tilapia* fry are collected downstream—those breeding in the pools. In Manimuthar and Amaravathy Reservoirs, the gillnet catches show up *Tilapia* of sizes 400·0—1,000·0 g (some time 1·5 kg. also). In Sathanur and Krishnagiri Reservoirs, *Tilapia* ou sizes 500·0 g. are common. In large irrigation sources like Odathurai tank (180 acres) with continuous inflow, outflow, *Tilapia* are not stunted but grow to a marketable size and over 250 g. It is probable that the receding water levels in sharply fluctuating reservoirs affect the breeding pits. In Vaigai, large breeding pits with a diameter of 1·0 m. and more and depth of 0·5 m. are exposed when water level falls off.

### Growth Rate.

Many workers wrongly consider *Tilapia* to be a fast growing species. Kelly (1957) thinks that a growth of 84·0 g. is 18 weeks (240 g.year) is fast and Raskemp (1960) considers 85—120 g in 8 months to be fast. Ling (1957) reported a growth of 200·0 g. in 1½ years in Thailand. Leroux (1961) found *Tilapia* to grow to only 12·5 cm. in the first year in Transvasal. Chacko and Krishnamoorthy (1954) who found it to grow to 22·0 cms. (110·0—140·0 g.) in eight months consider *Tilapia mossambica* a fast grower. Hickling (1962) cites that this fish grows to 200·0 to 290·0 g. in 320 days. The largest size noted in Lake Kariba was 32·0 cms. In Avanashi temple tank, *Tilapia* was first stocked in November 1957 had grown to 280·0 g. in eight months the next weight group being 110·0 g. All this shows that a fish growing to not more than 250·0 g. a year has been considered a rapid growing species. Even minor carps like *Cirrhina reba* grow larger in size in a year. Major carps like *Catla*, *rohu*, *Mrigal* attain at least six times this weight in a year in unfertilized waters. So also are *Cyprinus carpio*, *L. fimbriatus* and *C. cirrhosa*. *Chanos* grows much better than *Tilapia* and is much less of a nuisance. Neither is *Tilapia* a sport fish like the mahseers or *Barbus carnaticus* which though their growth is slow attain large sizes. Wells (1952) reported a growth of 32 oz. (900·0 g.) in the first year but this seems doubtful. In phosphate fertilized ponds, Hickling (1960) obtained a growth of 1 lb. in eight months but these were hybrid all-male *Tilapia mossambica*. Naumov (1961) cites that *Tilapia* grows well in brackish water, reaching 850 g. but this seems doubtful. In Egypt, the first year growth of *Tilapia mossambica* was only 60 g. (Koura and El Bolock 1958), which is certainly very poor when compared with its growth in our waters.

### Tilapia and Control of Algae

Vaas (1947) found *Tilapia mossambica* lived mainly on Phytoplankton and epihytic algae. Swingle (1957) noted that *Tilapia mossambica* was promising for control of filamentous algae such as *Pithophora* and that they also consumed *potamogeton*. Hickling (1961) states that *Tilapia mossambica* feeds mainly on green filamentas algae but not blue green algae and that other *Tilapia* species cleared a pond of Enhydrias weeds. Chacko and Krishnamoorthy (1952) applaud the " algicidal and mosquitocidal propensities " of this fish. Heard (1960), however, after studying four ponds concluded "its usefulness in controlling algae is undetermined ". This seems to be the correct appraisal. In a small cement cistern containing *Tilapia mossambica* in Bhavanisagar, *Hydrilla* disappeared and this was erroneously considered to be due to *Tilapia* but on many subsequent occasions this phenomenon was not at all noted. In natural ponds also *Tilapia* was not noted to reduce the intensity of *Hydrilla* weed. In a large number of ponds with blooms of blue green algae where *Tilapia* were teeming in thousands, those algae were not controlled. In such ponds, one could invariably see undigested faecal pallets of these algae.

## Tilapia—Present Experience—A Review

There existed two views on the question of suitability of *Tilapia* for culture. The pro-*Tilapia* views were mainly of those whose interest was in raising fish protein output in under-developed countries and make it available at cheap prices. They had to take into account vital factors such as tolerance of wide range of temperature and salinity, resistence to low oxygen tensions, ability to breed in confined waters, and non-fastidious feeding habits. The answer was found in *Tilapia*. Raskamp (1960) advocated large scale distribution of *Tilapia* in Netherlands New Guinea. Swingle (1960) found a high production of *Tilapia* ranging from 1,477—4,384 lb./acre in Alabama ponds mostly of undersized fishes. Likewise Kenny (1960) obtained yields of 1,700 kg./acre in West Indies but these were of sizes 2—10 cms. He suggested stocking of the tarpon (*Megalops* sp.) to control *Tilapia*. Heard (1960) however recorded a low production of 95·8 lb./acre in lakes and had this to say "the use of *Tilapia* in established lakes with balanced fish populations and stable fishing pressure may be somewhat limited". Ling (1957) while advocating the good qualities of *Tilapia* suggested the use of snakehead (murrel) and other predators to control it. Schuster (1952) declared that "natural regeneration high productivity, resistance to disease, and good feeding habits are factors which make *Tilapia* an attractive fish". His statement that "in tambaks......there also seems to be a possibility of growing *Tilapia* with *Chanos*", cannot be applied to ponds in Madras where *Chanos* culture has been ruined by the later intruder. Hickling (1962) remarks that "*Tilapia* is much less valuable than the beautiful white milk fish" Vaas and Hofstede (1952) found that in unmanured ponds, *Tilapia* interfered with Carp. In the philippines the competition which *Tilapia* offered to *Chanos* made its introduction a controversial issue (Anon, 1956). Yashouv (1958) found that *Tilapia* interfered with growth of carp but recommended its growth as secondary crop. Sarig (1955) also recorded the delaying of growth of carp in the presence of *Tilapia*. A very revealing situation has been presented by Ponguswana (1957) in Thailand. He obtained in Bangkhen Farm ponds yield of 5,600 kg. per acre per year of *Tilapia* with manuring but only 305 kg. out of this (5·5 per cent) consisted of fish of average weight 150·0 g. So he declared "obviously a big tonnage of thin fish with a large proportion of inedible material would be less valuable than a somewhat smaller crop in good condition". Swingle (1960) had a better idea of the utility of *Tilapia mossambica* when he stated "this species may have use as a forage fish for raising various predatory fishes and prevention of overcrowding would be a problem in its management". Wunder (1960) found that in Egyptian rice fields *Tilapia mossambica* had not shown any useful results. Chacko and Krishnamoorthy (1954) in India state that *Tilapia* co-existed with many carps, *Chanos*, *C. carpio*, etc., without detriment to them in Chetput pond but the observations were made only for the first year after the introduction. The conclusion of Menon *et al* (1959) that "*Tilapia* have not shown any deleterious effect on the indigenous carps" are based on inadequate ovbservations and are erroneous. Panikkar and Tampi (1954) however furnished evidence from other countries to prove the detrimental effects. Panikkar's (1952) warning "we are now not in a position to recommend the introduction of these species (*Tilapia*) without ruling out the indigenous species and without making sure that these species are not likely to affect local ecological conditions and cause adverse effect", should have been paid due attention. Frequent reproduction, breeding when small, and mouth breeding, result in large number of small fish which compete with adults for plankton and limit the development of large fish (Hickling, 1963). Periodical cropping by intensive fishing yielded a very high production—experienced in the ponds at Pudukkottai. Introduction of *Tilapia* resulted in lower yields year by year. But, for four months from April to July 1964, intensive fishing was done with spectacular results. In these four months the weight of fish exploited was more than double the average annual catch for the previous five years. The yield for these four months were as follows:—

| *Name of pond.* | *Yield kg./ha.* (*4 months*). |
|---|---|
| Kumundan Kulam .. | 1,850 |
| Kilnainar eri .. .. | 1,820 |
| Palaniandi Oorani .. | 2,770 |
| Pallavankulam .. .. | 1,220 |
| Malnainar eri .. .. | 1,553 |

There was another pond with a permanent turbidity giving very low yields but when *Tilapia* was cropped intensively, it yielded 540 kg./ha in four months. Two other ponds in the same town yielded 830 and 880 kg./ha. respectively in four months which was two to three times the previous annual yield. Intensive removal of marketable fish will thus lead to high yields of *Tilapia*. In Indonesian ponds polluted heavily by organic matter, a yield of 7,000 kg./ha. has been obtained with *Tilapia* (Huet, 1956). This author also considers the introduction of *Tilapia mossambica* in stagnant waters, a success. He says it possesses the advantage of reducing floating algae. The general yield is reported to be 500 to 1,000 kg./ha. In Israel, Yashouv (1958) records that continuous thinning gives a yield of 600 — 1,200 kg./ha. of *Tilapia mossambica*. Johnson (1959) records yields of 1,000 lb. acre / year of *Tilapia* in Mauritius when all male fish were stocked and liberal application of manure and fertilizer was made. He also stressed the need for population control. However, from our experience of *Tilapia* in impoundments, it is evident that they grow well to large sizes in these without becoming "runted". In all the reservoirs where these have been stocked, they have not affected the carp fishery or the other indegenous fishery. Cautious introductions of *Tilapia* in such impoundments could be undertaken. So also in waters in sub-tropical climates—at elevations of 3,000—4,500 feet.

## Certain Physiological aspects of Tilapia Mossambica

Oxygen consumption by *Tilapia* was found to be high, the lowest value being 0·43 mg./hr./g. of body weight for fingerlings of weight 17·0 g and 2·0 mg./hr./g of body weight for fry of size 0·1 g. Under the influence of 30 p.p.m. Veronal this could be reduced by 40 per cent. Direct transfer of *Tilapia* from fresh water to 2 per cent, NaCl medium did not affect the fish but if the concentration was 2·5 per cent Nacl the fish died. Even a short acclimitization to 1 per cent NaCl and transfer to 2·5 per cent Nacl resulted in its survival in the latter medium. *Tilapia* fry were not affected when the temperature of water was brought down from 28·0°C to 20·0°C but when it was brought down 15°C, suddenly all the fry died. The asphyxial level for *Tilapia* in sealed vessels was found to be 0·6 mg./1 for large ones and 0·85 mg./1 for fry. But in open vessels *Tilapia*, fingerlings withstood very low concentrations of oxygen for a number of days. They survived 0·2 mg./1 for 10 days.

*Tilapia* was resistant to a large number of inorganic Chemical poisons. The LC 100 is given below : Sodium cyanide 0·4 p.p.m., calcium hypochlorite 4·0 p.p.m., copper sulphate 5·0 p.p.m., sodium arsenite 60·0 p.p.m. (T.L.m. 56 p.p.m.) sodium hypocholorite 7 per cent solution, 400·0 p.p.m. and sodium sulphite 1,000·0 p.p.m. The LC 100 for certain organic chemicals is given below :—

Endrin 20 per cent 0·012 p.p.m. (T.L.m. 0·009 p.p.m.) Dieldrix, 0·06—0·08 p.p.m.(T.L.m. 0·05), Aldrix 40 per cent 0·05 p.p.m. (0·035 T.L.m.) chlordane, 0·07 p.p.m. (T.L.m. 0·055), Toxaphene 0·05 p.p.m. chloramine T. 28·0 p.p.m. Selective killing of *Tilapia* from ponds is thus rendered difficult because of its greater resistance to the toxicants. But it is less resistance to parathion than other fishes Lc 100 being 8·0 p.p.m. (T.L.m. 5·0 p.p.m.).

### Utility of Tilapia

In our ponds in Madras State, the initial higher yields of *Tilapia* were followed by lower yields in subsequent years. During the earlier years *Tilapia* was liked by the population, but subsequently with the decrease in size of *Tilapia* marketed, it has become the most un-popular fish and in fact even hostility to it has developed. Though *Tilapia* of sizes 250·0 g and over still attract good market, small-sized ones are sold for a song. In Madurai, 100 lb. of this would hardly fetch Rs. 2 (U.S. 40 c.). In Pudukkottai we found that 62 lb. of *Tilapia* was sold for just Rs. 2·75 , in the departmental pond in Madurai, though *Tilapia* production increase year by year for a few years the money value decreased year by year (Table II). The glut of small-sized *Tilapia* in Madurai led to some experiments on its conversion to fish meal. This fetched a higher price than fresh *Tilapia*. It would be interesting and useful to study the utility of *Tilapia* for making fish pastes or fish hydrolysates. In Manakudi backwaters *Tilapia* were introduced in 1958 and are thriving well. This should prove very useful as live bait for off-shore fishing in this area. From impounded waters with fluctuating water levels with inflow-outflow of water and in which indigenous predators exist, *Tilapia* could be stocked with advantage and harvested at large size of 0·5 to 1·0 kg. or more in gill nets.

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### *Summary.*

Introduction of *Tilapia mossambica* in Madras had very adversely affected carp culture and chanos culture in ponds. Population explosion and the consequent pressure for space and food reduce the size of *Tilapia*. In wild waters where indigenous predators such as notopterus, murrels, gobies, Wallago, etc., exist *Tilapia* of larger sizes are obtained because of population control. In large irrigation tanks and impoundments *Tilapia* grow to a large size and contribute to a large percentage of catches. Even in small ponds, intensive cropping up results in high yields of fish—*Tilapia*, as in Pudukkottai. In waters with overcrowded *Tilapia* populations, the oxygen tension is low. They do not seem to digest *Microcystis*, the predominent blue green algae in ponds.

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TABLE I.—*Hydrological conditions of ponds yielding* Tilapia *of less than 100 g. weight each.*

| *Name of pond.* (1) | *Location.* (2) | *Area.* (3) | *Temperature °C.* (4) | *pH.* (5) | *Dissolved oxygen mg./l.* (6) | *$HCO_3$ alkalinity mg./l.* (7) | *Electrical conductivity.* (8) | *Hardness ppm.* (9) | *Calcium mg./l.* (10) | *Chloride mg./l.* (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| Hanumantharayan temple tank. | Coimbatore | 0·2 | 33·0—26·5 | 8·5—9·0 | 15·2—8·8 | 274—259 | 800—775 | 186 | .. | 84·0—98·0 |
| Relief tank | Pennagaram | 0·5 | 30·2—28·4 | 7·6 | 9·8 | 153·6 | 370 | ND | 22·5 | 56·0 |
| Valaiveesi Teppam | Madurai City | 0·75 | 29·8 | 8·5 | 4·9 | 500·2 | 1,750 | ND | 92·6 | 100·0 |
| Sewage Fish farm | Madurai City | 0·1 | 33·8—35·8 | 9·0—9·6 | 16·6—30·0 | 312·1—54·9 | 1,895—1,750 | ND | 98·2—37·1 | 330·0—375·0 |
| K. K. Perumal Tank | Ponneri Town | 1·0 | 34·8 | 8·7 | 16·5 | 48·8 | 400 | .. | 48·2 | ND |
| Y.M.C.A. Pond | Madras City | 1·0 | 30·6 | 8·9 | 3·8 | 262·3 | 1,950 | .. | 54·6 | 376·0 |
| Kosavankulam | Karunkuzhi | 0·5 | 31·6 | 9·6 | 9·1 | 122·0 | 1,180 | .. | 25·7 | 196·0 |
| Vellaikulam | Kancheepuram | 3·0 | 27·0 | 8·5 | 5·0 | 247·1 | 805 | .. | 65·3 | 94·0 |
| Sarvatheertham | Kancheepuram | 4·0 | 31·6 | 8·9 | 9·5 | 98·5 | 460 | .. | 33·6 | 86· |
| Chettikulam | Kancheepuram | 2·5 | 31·8 | 9·6 | 38·8 | 33·6 | 495 | .. | 33·2 | 95·0 |
| Thimmarajakulam | Chingleput | 1·5 | 31·2 | 8·4 | 8·2 | 149·5 | 630 | .. | 45·4 | 58·0 |
| Karpoorachettikulam | Chingleput | 1·5 | 28·0 | 7·9 | 2·6 | 250·1 | 820 | .. | 50·8 | 250·0 |
| Veppankulam | Chingleput | 1·0 | 27·2 | 8·8 | 0·6 | 103·7 | 500 | .. | 0·0 | 300·0 |
| Theerthankulam | Tindivanam | 3·0 | 29·2 | 7·3 | 3·4 | 54·9 | 625 | 188 | 38·7 | 174·0 |
| Vellaikulam | Arni | 0·11 | 31·4 | 8·6 | 7·4 | 91·5 | 320 | 76 | ND | 52·0 |
| Fort Moat | Arni | 6·0 | 29·8—28·4 | 9·3 | 4·8—5·2 | 106·8—78·1 | 610 | 150 | 25·5 | 160·0 |
| Kallukatti tank | Karaikudi | 0·5 | 29·2—35·4 | 7·1—9·6 | 0·0—17·3 | 164·8—51·0 | 475 | 120 | 26·2 | 96·0—111·6 |
| Quarry Pool No. II | Virudhunagar | 0·66 | 31·8 | 9·2 | 3·2 | 326·14 | 3,000 | 340 | 34·1 | 916·0 |
| Quarry Pool No. III | Virudhunagar | 3·0 | 32·0 | 8·3 | 6·0 | 219·6 | 725 | 134 | 34·1 | 130·0 |
| Ayyankulam | Thanjavur | 2·0 | 29·2 | 7·5 | 0·0 | 219·6 | 490 | 104 | 52·1 | 91·0 |
| Anjaneyar Temple tank. | Villupuram | 4·0 | 34·4 | 8·3 | 4·0 | 372·1 | 1,075 | 164 | 42·7 | 181·0 |
| Sekkadikulam | Adirampatnam | 3·7 | 28·4 | 8·3 | 1·5 | 378·2 | 1,275 | 124 | 80·2 | 274·0 |
| Melnainareri | Pudukkottai | 2·0 | 35·4 | 7·9 | 0·0 | 85·4 | 2,100 | 280 | 44·1 | 564·0 |
| Sakkarai Theertham | Tiruvannamalai | 0·5 | 32·4 | 7·4 | 10·4 | 128·1 | 380·0 | 96·0 | 24·6 | 50·0 |
| Temple tank | Avanashi | 0·5 | 28·6—29·6 | 8·1—8·6 | 1·0—6·2 | 445—415 | .. | .. | .. | 36·0 |

TABLE II.—*Hydrological conditions of ponds yielding medium sized* **tilapia** *(weighing over 100 g. but less than 300 g.)*

| **Name of pond.** (1) | **Location.** (2) | *Area.* (3) | *Temperature °C.* (4) | *pH.* (5) | *Dissolved oxygen mg./1.* (6) | *$HCO_3$ alkalinity mg./1.* (7) | *Electrical conductivity.* (8) | *Hardness ppm.* (9) | *Calcium mg./1.* (10) | *Chloride mg./1.* (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| Pillaikulam | Adirampatnam | 6·6 | 28·6 | 8·6 | 0·8 | 420·9 | 1,350 | 116 | 86·2 | 272 |
| Kumudamkulam | Pudukkottai | 1·5 | 29·0 | 9·1 | 0·8 | 45·8 | 38·5 | 72 | 92·2 | 82 |
| Tirumakulam | Madurai | 4 | 30·4 | 8·0 | 4·6 | 201·3 | 620 | ND | 98·6 | 47·0 |
| Mariamman Teppam | Madurai | 17 | 30·4 | 9·6 | 1·8 | 256·2 | 2,650 | .. | 61·1 | 298 |
| Tirukkulam | Sirkazhi | 1·2 | 30·0 | 7·5 | 0·5 | 189·1 | 380 | 92 | 4·7 | 48 |
| West Moat | Thanjavur | 2·0 | 28·2 | 7·5 | 0·7 | 183 | 375 | .. | .. | .. |
| Webster Moat | Thanjavur | 4·0 | 29·0—28·0 | 8·8—7·9 | 0·01—0·1 | 219·6—289·0 | 825—695 | 170 | 61·5 | 180 |
| Teppakulam | Sivaganga | 6·0 | 32·0 | 8·8 | 1·3—0·0 | 103·7—201 | .. | 80 | 34·1 | 160 |
| Chekkadikulam | Sivaganga | 2·0 | 29·2 | 8·3 | 2·9 | 231·8 | 900 | 148 | 21·0 | 230 |
| Quarry Pool No. 1 | Virudhunagar | 0·48 | 31·2 | 9·0 | 9·8 | 167·8 | 2,125 | 70·0 | 44·1 | 536 |
| Sampadayankulam | Cheyyar | 0·50 | 30·0 | 7·2 | 4·0 | 61·0 | 145 | 60·0 | ND | 16·0 |
| Ayyankulam | Tiruvannamalai | 3·27 | 31·6—29·0 | 7·6—9·6 | 15·6—4·6 | 122—201<br>225·7 | 1,510—1,350 | **274**—102 | 43·6—45·4 | 302—315<br>220 |
| Tamaraikulam | Tiruvannamalai | 20·0 | 28·6—27·4<br>27·2 | 8·4—8·5<br>8·3 | 3·2—5·0 | 204·3—292·8<br>161·7 | 800—1,025 | 134—122<br>30·0 | 28·1—36·1 | 124—104 |
| Sandaimedu Pond | Chengam | 1·0 | 29·0 | 7·7 | 2·1 | 183·0 | 470 | 96·0 | 24·0 | 60·0 |
| Periatheppam | Valliyoor | 2·0 | 31·8 | 7·6 | 23·0 | 161·7 | 425 | 72 | 17·0 | 61·0 |
| Thattankulam | Karunguzhi | 1·90 | 31·8 | 9·6 | 7·0 | 152·5 | 1,250 | .. | 23·6 | 290·0 |
| Chennamalleswarar Temple tank. | Madras | 0·5 | 28·4 | 8·4 | ND. | 152·5 | .. | .. | .. | .. |
| Vellore Fort Moat | Vellore | 12·0 | .. | .. | .. | .. | .. | .. | .. | .. |
| **Pachemuthunadar Pond.** | Nagapattinam | 2·0 | 30·8 | 9·6 | 8·4 | 552·5 | **1,850** | 446 | 311 | **360** |

TABLE III.—*Hydrological conditions of ponds yielding large sized* **Tilapia** *(over 300g. in weight).*

| *Name of pond.* | *Location.* | *Area. (acres.)* | *Deph.* | | *Temperature °C.* | *pH.* | *Dissolved oxygen mg./1.* | *HCO3 alkalinity mg./1.* | *Electrical conductivity.* | *Hardness ppm.* | *Calcium mg./1.* | *Chloride mg./1.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Max.* | *Min.* | | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| **Saravana Poigai** | **Valliyoor** | 0·5 | 15 | 5 | 32·6 | 9·5 | 16·4 | 71·0 | 390 | 80 | 9·5 | 95 |
| Mandai Oorani | Vadugapatti | 1·0 | 8 | 2 | 32·4 | 8·5 | 17·4 | 195·2 | 580 | 150 | 52·1 | 72 |
| Teppakulam | Kulithalai | 1·67 | 8 | 2 | 31·4 | 7·3 | 1·1 | 311·1 | 680 | 181 | 43·1 | 78 |
| Sengulam | Mannargudi | 3·5 | 10 | 4 | 29·8—29·8<br>32·2 | 8·7—7·3 | 6·5—5·6 | 280·6—176·9 | 890 | 170 | 46·1—19·6 | 156—28·0 |
| Fort Moat | Chingleput | 7·0 | 12 | 3 | 28·2 | 9·5 | 6·2 | 82·4 | 255 | 130 | 22·5 | 120 |
| Cauvery Peak Pond | Shevroy's Yercaud. | 1·0 | 6 | 4 | 25·8- 26·4 | 6·5—9·3 | 11·5—9·0 | 21·4 74·1 | .. | .. | .. | 12—14 |
| Ananthasagaram Reservoir | Mettupalayam | 1·60 | 10 | 2 | 24·6 | 8·3 | 5·6 | 262·3 | 525 | .. | 31·6 | .. |
| Yercaud Lake | Shevroys' Yercaud. | 22·0 | 18 | 12 | 22·0—25·2 | 8·6—8·8 | 9·0—13·0 | 40·3—15·3 | 130·12 | 52 | Tr. 12·0 | 26·0 |
| Odathurai Reservoir | Odathurai | 1·90 | 18 | 6 | 25·4 | 8·7 | 6·6 | 271·5 | 525 | 28·40 | 41·6 | 64·0 |
| Manimuthar Reservoir | .... | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Amaravathy Reservoir | Kallapuram | 2,100 | 112 | 45 | 24·6 | 7·6 | 8·4 | 25 | 40 | 48 | Tr. | 7·0 |
| Sathanur Reservoir | Sathanur | 3,100 | 99 | 34 | 30·4 | 8·8 | 7·6 | 177·0 | 320—580 | 114—264 | 31·1 | 34·0—60·0 |
| **Vaigai Reservoir** | **Vaigai** | 5,980 | 96 | 26 | 26·4 | 7·8 | 6·7 | 51·9 | 125—140 | 65—114 | 17·5 | 8—20 |
| Krishnagiri | Muthur | 3,080 | 52 | 17 | 26·0—29·0 | 7·5—8·5 | 6·0—7·8 | 250—460 | 500 | 76—138 | 33·6 | 35—50 |

### TABLE IV.

*Fish yield and its money value is some ponds where* Tilapia *is the predominent species.*

| Year. (1) | Fish yield (2) LB. | Amount realized by sale. (3) RS. |
|---|---|---|
| *Mariamman Teppam*— | | |
| 1956–57 | 30,497 | 11,225 |
| 1957–58 | 25,397 | 6,138 |
| 1958–59 | 26,717 | 3,280 |
| 1959–60 | 37,356 | 1,537 |
| 1960–61 | 8,471 | 940 |
| 1961–62 | 15,469 | 860 |
| 1962–63 | 24,649 | 1,035 |
| *Pudukkottai tanks.*— | | |
| 1954–55 | 2,115 | 779 |
| 1955–56 | 2,468 | 864 |
| 1956–57 | 5,351 | 1,833 |
| 1957–58 | 5,385 | 1,306 |
| 1958–59 | 6 233 | 1,765 |
| 1959–60 | 6,766 | 1,582 |
| 1960–61 | 5,263 | 1,277 |
| 1961–62 | 9,102 | 327 |
| 1962–63 | 7,196 | 583 |

### TABLE V.

*Total yield of fish and weight of* Tilapia *in some ponds, lake and impoundments.*

| Year. (1) | Total fish yield. (2) LB. | Yield of Tilapia. (3) LB. | Numbers Tilapia. (4) |
|---|---|---|---|
| *Odathurai tank*— | | | |
| 1957–58 | 6,265 | Not known. | .. |
| 1958–59 | 7,886 | Do, | .. |
| 1959–60 | 7,681 | Do, | .. |
| 1960–61 | 14,029 | 6,043 | .. |
| 1961–62 | 9,843 | 4,857 | .. |
| 1962–63 | 11,531 | 4,868 | .. |
| *Ananthasagaram tank*— | | | |
| 1957–58 | 657 | 138 | .. |
| 1958–59 | 3,732 | 2,765 | .. |
| 1959–60 | 4,176 | Not known. | .. |
| 1960–61 | 7,529 | Do. | .. |
| 1961–62 | 8,242 | 7,954 | .. |
| 1962–63 | 5,110 | 2,954 | .. |
| *Kallukatti Pond*— | | | |
| 1959–60 | 1,712 | 1,706 | .. |
| 1960–61 | 1,735 | 1,707 | .. |
| 1961–62 | 499 | 417 | .. |
| 1962–63 | 1,778 | 1,208 | .. |

### TABLE V—*cont*

*Total yield of fish and weight of* Tilapia *in some ponds, take and impoundments*—cont.

| Year. (1) | Total fish yeild. (2) LB. | Yeild of Tilapia. (3) EB | Numbers Tilapia. (4) |
|---|---|---|---|
| *Theerthankulam Pond.*— | | | |
| 1956–57 | .. | Nil. | .. |
| 1957–58 | 2,637 | .. | .. |
| 1958–59 | 2,445 | 138 | .. |
| 1959–60 | 1,193 | 86 | .. |
| 1960–61 | 961 | 372 | .. |
| 1961–62 | .. | 289 | .. |
| *Veppankulam (Chingleput)*— | | | |
| 1958–59 | 144 | 144 | 419 |
| 1959–60 | 393 | 393 | 1,120 |
| 1960–61 | 225 | 225 | 933 |
| 1961–62 | 420 | 410 | 2,455 |

### TABLE VI.

*Data on the fish yield and* Tilapia *catches in some ponds.*

| Year. (1) | Total fish yields. (2) LB. | Tilapia. Total Weight per year. (3) LB. | Tilapia. Number. (4) | Tilapia. Average weight. (5) LB. |
|---|---|---|---|---|
| *Yercaud lake (upland lake)*— | | | | |
| 1956–57 | 524 | Nil. | Nil. | Nil. |
| 1957–58 | 484 | 1 | 494* | .. |
| 1958–59 | 756 | 304·5 | 841 | 0·36 |
| 1959–60 | 890 | 698·5 | 1,871 | 0·37 |
| 1960–61 | 300 | 273 | 716 | 0·38 |
| 1961–62 | 497 | 203 | 283 | 0·72 |
| 1962–63 | 538 | 315 | 419 | 0·75 |
| *Ayyankulam (Tiruvannamalai)*— | | | | |
| 1958–59 | 2,878¾ | 303¾ | 1,835 | 0·17 |
| 1959–60 | 4,860 | 4,589 | 28,299 | 0·16 |
| 1960–61 | 8,160 | 6,527 | 39,952 | 0·16 |
| 1961–62 | 3,841 | 1,997 | 16,654 | 0·12 |
| 1962–63 | 4,191 | 1,504 | 8,581 | 0·17 |
| *Tamaraikulam (Tiruvannamalai)*— | | | | |
| 1958–59 | 5,021 | 912 | 5,862 | 0·15 |
| 1959–60 | 5,703 | 3,902 | 24,067 | 0·16 |
| 1960–61 | 3,227 | 1,659 | 10,069 | 0·17 |
| 1961–62 | 2,921 | 2,500 | 14,910 | 0·17 |
| 1962–63 | 3,768 | 1,686 | 9,960 | 0·17 |

* Fingerlings.

# A NOTE ON THE PRESERVATIVE ACTION OF ACETIC ACID APPLIED AS A SPRAY OVER SALTED FISH

BY

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## Introduction.

Though a variety of chemical preservatives and anti-oxidants have been permitted in food preservation, very little use of these have so far been made in fish preservation especially in preparing salted and dried fish. The literature concerning chemical preservation of fish has been reviewed recently by Tarr (1961). The use of inorganic and organic acids to control bacterial spoilage of fish was suggested by Nadeau (1939). The recent works of Sen *et. al.* (1961) and Suryanarayana Rao and Valsan (1962) have indicated the usefulness of Sodium propionate and propionic acid as effective chemical adjuncts for extending storage life of salted and dried mackeral. Bersamin *et. al.* (1961) found Sarbistat useful in preventing the growth of yeasts and moulds among the common dried fishery products such as *Sardinella* and *Decapterus* species. Nicholson (1930), found that the addition of one part of acetic acid to 250 parts of boric acid would improve the preservative action of the latter. Aiso (1951), Tetsumoto *et. al.* (1953) and Tarr *et. al.* (1950) found 0·1 to 0·5 per cent Dehydroacetic acid incorporated in flesh slightly effective in inhabiting bacterial spoilage of fish. Similar observations with monobromacetic acid were made by Tarr *et. al.* (1950) and Rowan *et. al.* (1953). The use of Vinegar in the preparation of fish pickles in our houses is well known. Experiments were therefore conducted by the present authors to find out the effect of a spray of one per cent acetic acid over salted fish before drying on the qualities of the salt-cured fish. The results of these experiment are discuss in this communication.

## Material and methods.

The investigations were carried out with two varieties of marine fishes, *Lactarius sp.* and *Dussumieria sp.* The specimens for the investigation were obtained fresh from the local landings and were split along the ventral side and guts removed. These were then washed and salted. The salt : fish ratio for *Lactarius sp.* was 1 : 4 and that for *Dussumieria sp.* 1 : 8 by weight.

The salted fish was then divided into two lots. Of these one lot was allowed to remain overnight in a tub so as to be in contact with the self-brine formed. After curing, the fish was dried in the sun for three days. The other half of the salted fish was sprayed with a solution of one per cent acetic acid using a fine sprayer immediately after salting. Further processing was done by the same method described above. The dried fish was stored in glass containers with lids and examined at monthly intervals for a storage period of up to six months. Moisture was determined as per A.O.A.C. (1958) method. T.V.B.N. and T.M.A.N. were estimated by the micro diffusion method of Conway (1947) and the organoleptic rating of the products was done as per scoring system of Venkataraman and Vasavan (1955).

## Results and Discussions.

The analytical data on the progress of spoilage in the two sets of samples for *Lactarius sp.* and *Dussumieria sp.* are shown in Tables I and II respectively in annexure.

It will be seen from these data that as far as the chemical indices of spoilage, viz., T.V.B.N., and T.M.A.N., were concerned the acetic acid treatment did not appear to have effected any improvement. But based on organoleptic tests, the acetic acid treated samples scored a higher rating than the corresponding control samples. The acetic acid treated samples were more attractive in appearance and had better flavour than the untreated control samples, the difference between the two samples becoming more marked from the third month onwards. This may be due to the fact that since acetic acid was applied only as a spray, it did not penetrate the flesh deep enough to effect uniform improvement in the quality of the product. Probably the effectiveness of the chemical was restricted to the fish surface only and the apparent better appearance gave a misleading idea of the real quality of the fish. However the usefulness of acetic acid in preservation of salted fish products has been indicated by Notevarp *et. al.* (1934). Similar observations and limited protection against moulds by propionic acid have also been reported by Valsan *et. al.* (1961).

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TABLE I.

*Showing data on the progress of spoilage in salted Dussumieria sp. sprayed with Acetic acid prior to curing.*

| Sample. | *Period of storage.* | | | | | | | | | | | | *Remarks.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *One month.* | | *Two months.* | | *Three months.* | | *Four months.* | | *Five months.* | | *Six months.* | | |
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| Moisture (per cent) .. .. | 36·01 | 36·88 | 36·18 | 36·75 | 36·28 | 37·63 | 35·30 | 37·50 | 37·09 | 37·60 | 37·08 | 37·62 | *A*=Control sample. |
| T.V.B.N. (mgm./cent) .. .. | 87·5 | 90·0 | 112·0 | 112·5 | 163·0 | 172·0 | 271·0 | 287·5 | 375·0 | 329·0 | 398·0 | 397·0 | |
| T.M.A.N. (mgm./cent) .. .. | 21·0 | 20·0 | 27·5 | 30·0 | 44·0 | 43·5 | 62·0 | 65·0 | 77·0 | 82·5 | 116·5 | 109·5 | *B*=Acetic acid treated sample. |
| Organolephic Test score (Max. 30) | 30·0 | 30·0 | 28·0 | 28·0 | 23·0 | 29·0 | 20·0 | 24·0 | 18·0 | 21·0 | 12·0 | 13·0 | |

TABLE II.

*Showing data on the progress of spoilage in salted Lactarius sp. sprayed with Acetic acid prior to curing.*

| *Sample.* | *Period of storage.* | | | | | |
|---|---|---|---|---|---|---|
| | *One month.* | | *Two months.* | | *Three months.* | |
| | *A* | *B* | *A* | *B* | *A* | *B* |
| (1) | (1) | (2) | (3) | (5) | (6) | (7) |
| Moisture (per cent) .. .. | 37·36 | 38·16 | 37·34 | 38·21 | 37·72 | 38·39 |
| T.V.B.N. (mgm./cent) .. .. | 120·0 | 118·0 | 145·0 | 141·0 | 171·0 | 163·0 |
| T.M.A.N. (mgm./cent) .. .. | 27·5 | 28·0 | 38·0 | 35·0 | 40·0 | 38·0 |
| Organolephic Test Score (Max. 30) | 29·0 | 29·0 | 26·0 | 27·0 | 22·0 | 25·0 |

| *Sample.* | *Period of storage.* | | | | | | *Remarks.* |
|---|---|---|---|---|---|---|---|
| | *Four months.* | | *Five months.* | | *Six months.* | | |
| | *A* | *B* | *A* | *B* | *A* | *B* | |
| | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| Moisture (per cent) .. .. | 38·18 | 38·27 | 38·69 | 38·26 | 38·68 | 38·22 | *A*=Control sample. |
| T.V.B.N. (mgm./cent) .. .. | 262·0 | 260·0 | 383·0 | 382·0 | 420·5 | 402·5 | |
| T.M.A.N. (mgm./cent) .. .. | 55·0 | 50·0 | 95·0 | 91·5 | 117·0 | 110·5 | *B*=Acetic acid treated sample. |
| Organolephic Test Score (Max. 30) | 18·0 | 23·0 | 16·0 | 20·0 | 12·0 | 14·0 | |

# ON THE EFFICIENCY OF THE "METTUR RANGOON" NETS IN THE BHAVANISAGAR RESERVOIR.

BY

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Multipurpose artificial impoundments are potential sources of fish production. There are many such in *India* and almost all of them without exception have been taken up for fish culture. An understanding of the existing fishery before impoundment, the trend in recruitment of the indigenous fishery after the formation of the water spread, the programme of introduction of exotic fishes, study of the breeding grounds, productivity and biomass variations over different seasons in relation to water exchange are all factors that decide the fishery wealth of these artificial impoundments and are to be constantly studied. The Hydrobiological station at Bhavanisagar is investigating on these lines so that a management policy could be laid out for each type of our reservoirs (Ranganathan *et al* 1963 and Sreenivasan 1964). A simultaneous analysis of the fishing efficiency with different gear is equally essential for a study of the trend of the unit catch effort and also for evolving the best fishing gear.

It is generally felt that the technique employed by the inland fishermen in Madras State for exploiting the major reservoirs like Mettur and Bhavanisagar are capable of further improvement. Yet no better solution than the "Rangoon" net of Mettur has been suggested as an effective alternative especially when the bottom is uneven, full of rocks and submerged trees. Gulbadmov (1961) in his report to the Government of India on "Improvement of Fishing Techniques in Inland Reservoirs of India" considers the nets used by the Mettur and Bhavanisagar fishermen capable of improvement and recommends even a gradual substitution of his new "Sebgul" I or II. His comparison of the average catch of a fisherman at Mettur with that of his "Sebgul" net is incomplete, in that data are not available with reference to water level and seasons of the fishery. Even if Mettur Fishermen have no technical background, their instinctive acumen are so much that they have evolved the best mesh size to suit each fishery as evidenced by the nets used in 1964 and 1965 for catching the 20 to 25 kgs. *Catla*, and 14 to 16 kgs. *Mrigal*. It is highly doubtful if "Sebgul net' II with 3·5 bar will ever catch *Cirrhina cirrhosa*, and *Barbus dubius* since the biggest of the former in Mettur is of 4·0 kgs. and is caught only in the 2″ and 2½″ mesh, the fish being definitely small for 3·5″ to 5″ nets. *Barbus dubius* of more than 1·0 kg. has never occured in Mettur in recent years and the biggest size of 3 to 5 kg . are always caught in 2½″ mesh bar in Bhavanisagar. It was therefore felt by us that a complete account of fishing operations in a reservoir will be of value so that comparative studies could be instituted elsewhere to evolve the efficient methods in reservoir fishing.

Bhavanisagar, a reservoir of 30 square miles in Madras State is formed as a result of the damming of the Bhavani and Moyar Rivers draining from the Nilgiris plateau. A fairly accurate idea of the water line at different contours and the nature of the bed is available (Ranganathan *et al* 1963). The FRL contour line is +915′ and capable of being raised to +920′ while the bed level of the river at the Dam site is +797′. Typical of artificial impoundments, the submerged bed is very uneven, strewn with rocks, boulders and even small hillocks all over. Submerged basements of villages, complete fort with a temple and forests strewn with big trees especially in the area drained by the now submerged Bhavani are characteristic of the bottom. (Photos) Seining of any sort is hence impossible.

The reservoir was developed for its fishery from the year 1952 by conserving the indigenous fishery of *Barbus dubius, Macrones aor, Wallagonia attu* and *Labeo bata.* These fisheries are now well established in this reservoir. *Labeo calbasu, Catla catla, Cirrhina mrigala* and *Labeo rohita* were systematically stocked. Of these *Labeo calbasu* has got established well while the others are yet to be established. *Barbus dubius* breeds between September and November migrating for a short distance up the Bhavani and the peak fishery is around these months. *Macrones aor* dominates the catches between December and May, a period of their gonadial maturation and local migration especially in the Moyar side. *Labeo calbasu* along with *Wallagonia attu* and the carps *Catla, Mrigal, Rohu* and *Labeo fimbriatus* are always to be anticipated when freshes appear especially in the Bhavani side. It is now possible to pin point the movement of each fishery with reference to breeding or feeding migration and this has enabled us to operate the fishing units to the best advantage.

Reduced to terms of the unit effort the results of 1964 fishing in Bhavanisagar reservoir is reflected in Table 1. The average daily landing of each unit in 1964 was 46·35 *kgs.* The other limiting factors in addition to the fishing efficiency of the gear are the water level, the rate and nature of inflow and outflow and turbidity. The unit effort was calculated on the basis of total number of units employed each month. Thus during January 1964, three units operated each day for 31 days (93 units in January). Each unit consisted of one coracle, a basket shaped craft lined by hide and operated by two fishermen, 20 "Rangoon" nets consisting of ten 2½″, Five 2″ and five *catla* nets of 4″ meshes prescribed as optimum. The standardized specifications of these nets are given in Table 2 (*a*). Before the nets were operated care was taken to give the correct co-efficient of 50 per cent hanging. The loose hanging and slipping were avoided by tying the knot at every 24″ in the float line. The initial cost of rigging one unit was around Rs. 1,000, Rs. 900 for nets and Rs. 100 for the coracle. The fishermen were paid each Rs. 70 a month and the expenditure on each unit a year is 140×12=1,680+1,000=2,680 rupees. The fish were disposed of at the rate of 92 Paise per kilogram and each unit earned on an average of Rs. 10,000 a year during the period under discussion. In addition, during the months of May to July the fishing effort was increased as can be seen from the table by engaging some units of the Mettur fishermen. There was not so much of net standardization with Mettur fishermen as in the department. The nets used in general by them were of the specifications given in Table 2 (*b*).

The overall result of fishing in 1964 involving a total unit effort of 1920 was the landings of 89 tons of fish (Table 3) Each unit effort of fishing costs the Government Rs. 8 aggregating to Rs. 16,000 and the total revenue on account of sale at 92 paise was Rs. 87,200. The species anticipated to form the main fishery based on hydrobiological studies were truely reflected in the catches, . Thus 19,673 *Barbus dubius* (24,173 kgs.) 3,213 *Labeo calbasu* (11,274 kgs.) 2,319 *Wallagonia attu* (9,071 kgs.) and 10,695 *Macrones aor* (18,959 kgs.) accounted for the more dominant catches. There was a significant increase in catches during May, June and July in the low level conditions of 846 feet to 871 feet level influenced by occasional floods. When water level conditions become stable, the increase in catches of *Barbus dubius* from November to December is on account of the return of spent voraciously feeding spawners. Such observations were made on *Macrones aor,* the season for large scale fishing being around the breeding months of November to March. *Labeo bata* was successfully fished with 2″ mesh nets in May (1,057 fish weighing 1,109 kgs.) and December (1,383 fish weighing 1,042 kgs.) during their upward breeding migration consequent on sporadic floods. The fishery was followed by a large scale breeding of the fish about 10 to 15 miles above the place of capture as was confirmed by a heavy collection of spawn of the same species A major carp fishery of *Labeo calbasu, Catla catla, Cirrhina mrigala Labeo bata* and *Labeo fimbriatus* was anticipated and achieved between May and June.

Sudden floods and heavy winds affected adversely the catches especially during May and June. The general practice of the fishermen was to relay the nets which got rolled immediately after the wind or flood. Two sets of 5 experimental nets were operated under identical conditions, the first one using the ordinary nets and attending to relaying after wind and flood. In the second set the nets were framed, barrel shaped thermacole floats at a distance of 3 metres in the float line and small stone sinkers in lead line were used. This effectively prevented the rolling of nets. The comparative results are shown in Table 4 (a and b). During the month of June one set of ordinary nets landed 858 fishes weighing 2,374 kgs. as against 3,271 fishes weighing 8,127 landed by the same number of nets rigged with floats and sinkers. The results in May were still better. 5,259 fishes weighing 10,301 kgs. were accounted for by the improved nets compared to 1,143 fish weighing 2,586 kgs. from the nets handicapped by rolling on account of winds and floods. The catch of the bigger sized fish by ordinary nets is significant. Once the conditions became normal as regards flow and wind there was no appreciable difference in the landings between the "Sebgul" nets and the Mettur net with advance care on framing and felling.

The results of the study made in regard to the species of fish caught in relation to the mesh of the net is indicated in the Table 5. *Catla catla* weighing 10 to 17 kgs., *Cirrhina mrigala* weighing 10 to 14 kgs. and *Labeo callasu* 8 to 12 kgs. and *Wallagonia attu* 10 to 20 kgs. were always caught in the Catla net of 4″ mesh. 2½″ mesh yielded the maximum catches in Bhavanisagar Reservoir accounting for the *Barbus dubius*, *Macrones aor*, *Labeo kontius*, *Wallagonia attu* and *Labeo calbasu* and the 2″ mesh landed *Labeo bata* and the two-year old *Barbus dubius* and *Labeo kontius*. The use of the 2″ net must be with reference to *Labeo bata* only, otherwise if they are used indiscriminately the smaller sized *Labeo calbasu*, *Catla catla* and *Cirrhina mrigala* are liable to be captured. These observations are of practical value in deciding the mesh for each type of fishery in a reservoir in relation to size of the fish.

Intensification of efforts are always called for when best fishing conditions prevail. Low level with flux of even little flood water is one. The results of one such fishing in low level of ·844·90 and one in high levels of F.R.L.+915·60 contour level, in the same place using the same number of nets but with mesh to suit the fishery of that period is given in Table 6 and 7. The catch per unit effort was high in March and April, due to the persistant low level condition (859·06′ to 844·06). The unit effort catch of 233 kgs. and 130 kgs. in March and April is explained by the fact that this is the period of maximum catch of *Macrones aor* and also due to use of new Catla and Rangoon nets supplied in March 1964 accounting for a catch of *Catla catla*. *Labeo calbasu* and *Barbus dubius*. Six days fishing near Kothikombu yielded 1,823 fish weighing 4,422·5 kgs. at 844.90 feet level while in the same place at 915·60 feet level yield was only 1,732 fishes weighing 2,439·5 kgs. Comparative catch data under the same level conditions but in different area are given in table **7** and 8. Six days in the Moyar side (Table 8) resulted in the capture of 1,465 fishes weighing 1,933·00 kgs. The submerged Bhavani area yielded (*see* Table 7) 1,732 fishes weighing 2,439 kg.

A map of the Bhavanisagar reservoir, indicating the best fishing area under different contour levels, the nature and season of the fishery is appended.

### *Acknowledgement.*

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### *Discussion.*

Interesting data of practical value have been obtained in analysing the fishing results in the Bhavanisagar reservoir, Madras State.

During 1964 a total quantity of 89 metric tons of fish were landed involving 1920 unit effort of fishing. Each unit effort is one day's fishing with one coracle, 2 fishermen and between 1,000 to 1,250 metres of " Rangoon net ". Each unit effort costs nearly Rs. 8. The total fishing expenditure on account of these efforts was Rs. 16,000 nearly, while the receipt by way of the sale of fish was Rs. 87,000.

Maximum efficiency was assured by giving a 50 per cent hanging and avoiding slipping at the head rope by binding at regular intervals.

The hydrobiological investigations gave accurate idea of the fisheries in general and areas of congregation on account of breeding and feeding migrations. Nets were always laid at places best suited taking into account the results of the above study.

An attempt has been made to standardise the nets so that all workers can compare their results. This will help in ultimately bringing a standard to define each unit effort, for multipurpose reservoirs in India.

Any appreciable superiority of the ' Sebgul ' nets over the Rangoon nets cannot be established on ordinary days. Floats on the head rope and sinkers at the bottom prevented rolling of the nets during floods and winds, thus saving the trouble of attending to relaying often.

The results of fishing under low and high level conditions and the richness of the Bhavani fishing ground over Moyar area are all given in different tables.

Further experiments on fishing with drift nets at different depths, with electrical lights using different colours and fishing with current are to be tried. Till such time as the efficiency of the above experiments are proved beyond doubt, Rangoon nets properly hanged are the best for artificial impoundments in river basins characterised by uneven bottom and submerged fishing obstacles.

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## FISHING CENTRES IN BHAVANISAGAR RESERVOIR FOR THE YEAR 1964.

(Illustrations to Figure.)

### GROUP A.

*Bhavani side.*

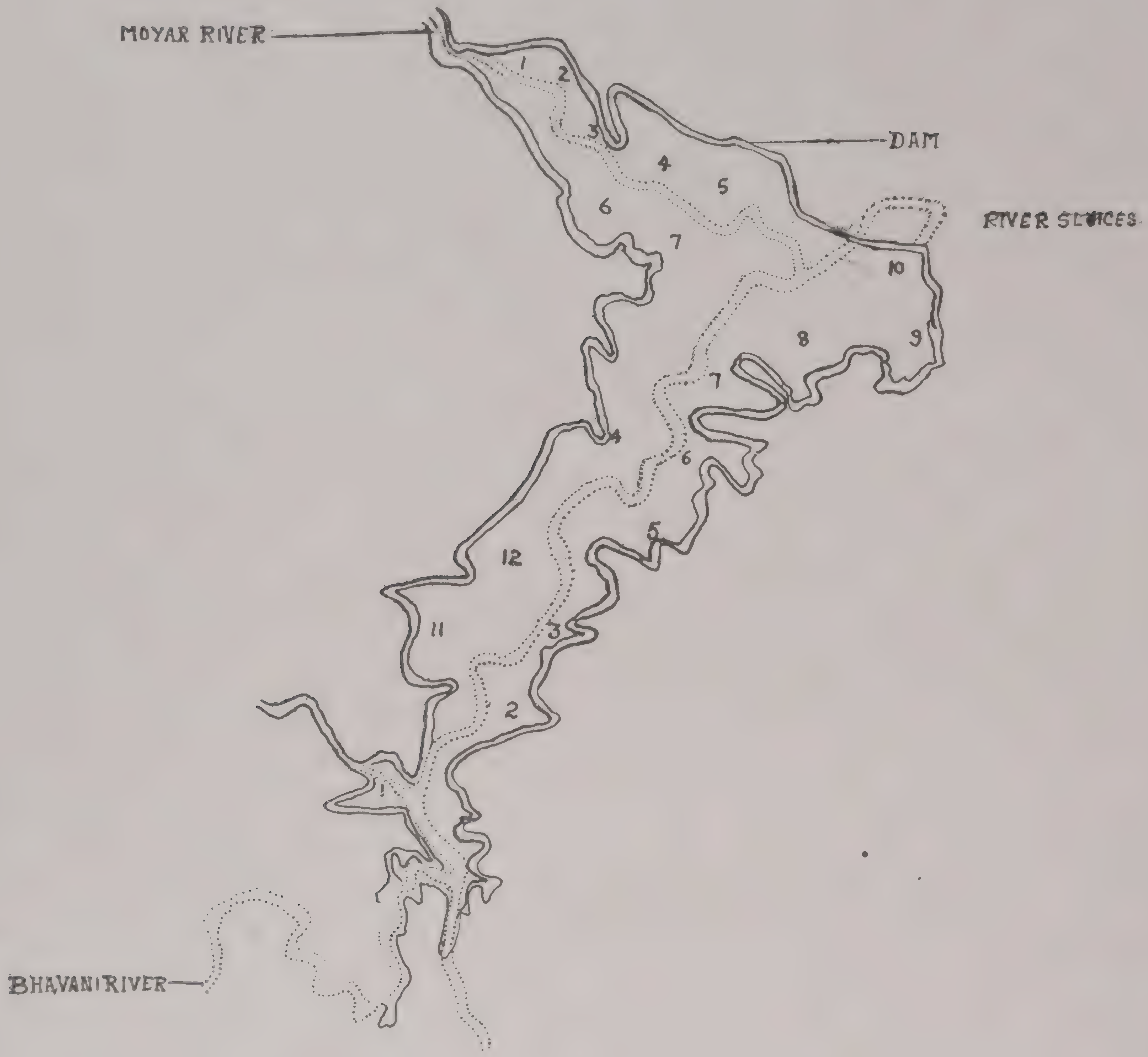
| *Fishing Centres.* | *Specifications of nets recommended for use.* | *Nature of fishery.* |
|---|---|---|
| 1 Emanpatti chalai | 25 per cent of the nets 4″ Catla, 25 per cent 2″ mesh for *Labeo bata* and 50 per cent Rangoon nets 2½″ mesh. | *Barbus dubius, Wallagonia attu, Labeo calibasu, Labeo bata, Catla catla, Cirrhinai mrigala, Macrones aor* in order of importance. |
| 2 Thattapallam | .... | .... |
| 3 Kothikombu | .... | .... |
| 4 Dananaykankottai | Centres 1 and 2, 11 and 12 functional in between 890′ and 920′ water level. | |
| 5 Nellimokkai | | |
| 6 Othapanaikadu | Centres 3 to 10 functional in between 835′ to 890′ water level. | |
| 7 Palayavadavalli | | |
| 8 Kodapalayam | | |
| 9 Ammapalayam | | |
| 10 Water House | | |
| 11 Chinnavarambu | | |
| 12 Periavarambu | | |

### GROUP B.

*Moyar side.*

| *Fishing Centres.* | *Specifications of nets recommended for use.* | *Nature of fishery.* |
|---|---|---|
| 1 Beruduraipatti | Rangoon nets 2½″ mesh all the year round and 4″ mesh Catla net between May and July for major carps and Wallagonia attu. | *Macrones aor* and *Barbus dubius* dominant. |
| 2 Benchi Pallam | Do. | Major carps *Labeo calbasu* and *Wallagonia attu.* |
| 3 Boodikuppam | Do. | .... |
| 4 Karai Mokkai | Do. | .... |
| Uppu Pallam | Centres 1 to 3 functional in between 890′ to 920′ level. | |
| Peerkadavu | Centres 4 to 7 functional below 890′ level. | |
| 7 Pattaramangalam | | |

## FISHING CENTRES IN BHAVANISAGAR RESERVOIR FOR THE YEAR 1964.



### GROUP A—BHAVANI SIDE.

1 Emmanpattichalai
2 Thattapallam
3 Kothikombu
4 Dinanayakankottai
5 Neelimokkai
6 Othapanaikadu
7 Old Vadavalli
8 Kodapalayam
9 Ammapalayam
10 Water House
11 Chinnavarambu
12 Periavarambu

### GROUP B—MOYAR SIDE.

1 Beruduraipatti
2 Benchipallam
3 Boodikuppam
4 Karaimokkai
5 Uppupallam
6 Peerkadauv
7 Pattaramangalam Pudoor.

### TABLE I.

*Monthwise landings of fish with Rangoon nets in Bhavanisagar in relation to unit effort.*

| *Months.* (1) | *Unit effort.* | *Fish landings.* *Number.* | *Fish landings.* *Weight.* (IN KGS). |
|---|---|---|---|
| 1964— | | | |
| January | 93 | 3,651 | 5,309·75 |
| February | 87 | 4,659 | 7,163·25 |
| March | 93 | 8,447 | 11,999·00 |
| April | 120 | 7,096 | 15,075·00 |
| May | 216 | 5,354 | 10,967·75 |
| June | 360 | 4,670 | 11,524·00 |
| July | 186 | 2,400 | 8,038·50 |
| August | 186 | 1,981 | 4,473·25 |
| September | 150 | 1,636 | 2,301·50 |
| October | 155 | 744 | 1,165·25 |
| November | 150 | 1,900 | 2,594·75 |
| December | 124 | 5,962 | 8,389·50 |
| Total | 1,920 | 48,500 | 89,001·50 |

NOTE.—Average catch by one unit=46·354 kgs.

### TABLE 2 (*a*)

BHAVANISAGAR FISHING—SPECIFICATIONS OF NETS USED AND STANDARDISED (DEPARTMENTAL).

*Garware—Garnyle.*

| *Nets.* (1) | *Length of nets (in metres.)* (2) | *Weight of yarn per net (in kilograms).* (3) | *Mesh size.* (4) | *Number of meshes in* *length.* (5) | *Number of meshes in* *row.* (6) | *Code number.* (7) | *Breaking strength (in kgs.)* (8) |
|---|---|---|---|---|---|---|---|
| 1 Rangoon net | 50 | 0·587 | 2″ | 1,000 | 45 | 2<br>(210 × 1 × 3) | 4·5 |
| 2 Rangoon net | 40 | 0·766 | 2½″ | 750 | 35 | 2 | 4·5 |
| 3 Catla net | 100 | 0·520 | 4″ | 500 | 25 | 3<br>(210 × 4) | 6·0 |

### TABLE 2 (*b*).

BHAVANISAGAR FISHING—SPECIFICATIONS OF NETS USED BY METTUR FISHERMEN AND BY SPECIAL UNITS ON SHARE BASIS.

*Garware—Garnyle.*

| *Nets.* (1) | *Length of nets (in metres).* (2) | *Weight of yarn per net (in kilograms.* (3) | *Mesh size.* (4) | *Number of meshes in* *length.* (5) | *Number of meshes in* *row.* (6) | *Code number* (7) | *Breaking strength (in kgs).* (8) |
|---|---|---|---|---|---|---|---|
| 1 Catla net | 50 | 1·0 | 5″ | 400 | 17 | 3 or 4<br>(250 × 3 × 3)<br>or (250 × 4 × 3) | 13·6 to 17·6 |
| 2 Catla net | 65 | 1·0 | 4·5″ | 594 | 18 | Do. | Do. |
| 3 Catla net | 65 | 1·0 | 7″ | 317 | 17 | Do. | Do. |
| 4 Catla net | 60 | 1·0 | 4″ | 575 | 25 | Do. | Do. |
| 5 Rangoon net | 30 | 0·5 | 4″ | 580 | 35 | 1<br>(250 × 3 or<br>210 × 2 × 2<br>or 210 × 4. | 6 |
| 6 Rangoon net | 35 | 0·5 | 5″ | 570 | 33 | Do. | Do |

## TABLE 3.

*Monthwar data of total fish landings in Bhavanisagar Reservoir for 1964.*

| *Serial number and name of the fish.* | *January.* | | *February.* | | *March.* | | *April.* | |
|---|---|---|---|---|---|---|---|---|
| | * 893·29 | * 876·10 | 875·74 * | 859·00 | 859·06 * | 848·22 | 849·70 * | 844·96 |
| | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 Barbus dubius .. .. .. .. | 2,584 | 3,327·00 | 2,752 | 3,753·25 | 4,514 | 6,145·00 | 1,997 | 2,641·60 |
| 2 Barbus carnaticus .. .. .. .. | 51 | 64·00 | 38 | 42·50 | 44 | 43·00 | 295 | 218·00 |
| 3 Barbus hexagonalepis .. .. .. | 37 | 90·75 | 12 | 27·00 | 11 | 20·75 | 116 | 181·00 |
| 4 Barbus tor .. .. .. .. .. | 11 | 23·25 | 18 | 52·25 | 12 | 15·00 | 18 | 44·75 |
| 5 Barbus sarana and others .. .. .. | 1 | 0·25 | 1 | 0·50 | 10 | 6·50 | 1 | 0·50 |
| 6 Labeo kontius .. .. .. .. | 56 | 52·75 | 146 | 134·75 | 437 | 396·75 | 561 | 582·00 |
| 7 Labeo fimbriatus .. .. .. | 31 | 94·75 | 23 | 66·00 | 3 | 6·00 | 286 | 1,053·00 |
| 8 Labeo calbasu .. .. .. .. | 89 | 316·25 | 154 | 590·75 | 71 | 251·00 | 626 | 2,380·00 |
| 9 Labeo bata .. .. .. .. .. | 10 | 9·00 | 37 | 37·75 | 502 | 487·00 | 985 | 879·75 |
| 10 Labeo paral and others .. .. .. | 13 | 15·15 | .. | .. | .. | .. | 17 | 24·50 |
| 11 Wallago attu .. .. .. .. | 66 | 181·00 | 131 | 263·75 | 291 | 549·25 | 291 | 1,010·00 |
| 12 Mystus aor .. .. .. .. | 679 | 1,024·50 | 1,330 | 2,073·25 | 2,488 | 3,872·50 | 1,585 | 2,666·00 |
| 13 Catla catla .. .. .. .. .. | 3 | 31·50 | 3 | 58·50 | 9 | 159·25 | 138 | 2,383·00 |
| 14 Labeo rohita .. .. .. .. | .. | .. | 2 | 17·00 | 4 | 26·00 | 45 | 510·50 |
| 15 Cirrhina cirrhosa .. .. .. .. | 4 | 10·25 | 4 | 15·75 | 2 | 7·00 | 30 | 89·00 |
| 16 Cirrhina mrigala .. .. .. .. | 8 | 47·75 | 4 | 29·25 | .. | .. | 56 | 383·50 |
| 17 Eel .. .. .. .. .. .. | 5 | 12·25 | .. | .. | .. | .. | .. | .. |
| 18 Murrel .. .. .. .. .. .. | 2 | 6·75 | .. | .. | .. | .. | 1 | 2·50 |
| 19 Mirror carp .. .. .. .. .. | .. | .. | .. | .. | .. | .. | 1 | 12·00 |
| 20 Etroplus and others .. .. .. | 1 | 0·25 | 4 | 1·00 | 49 | 14·00 | 47 | 13·50 |
| Total .. | 3,651 | 5,309·75 | 4,659 | 7,163·25 | 8,447 | 11,999·00 | 1,796 | 15,075·00 |

*Water level in the reservoir.

| (1)—*cont.* | *May.* |  | *June.* |  | *July.* |  | *August.* |  |
|---|---|---|---|---|---|---|---|---|
|  | * 846·32—849·36 |  | 846·72—839·63 |  | 871·72—842·98 |  | 918·06—871·33 |  |
|  | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* |
|  | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
| 1 Barbus dubius | 1,247 | 1,663·50 | 1,164 | 1,616·00 | 542 | 651·25 | 647 | 717·75 |
| 2 Barbus carnaticus | 52 | 52·75 | 17 | 34·00 | 21 | 13·50 | 52 | 58·00 |
| 3 Barbus hexagonalepis | 80 | 174·50 | 81 | 176·00 | 77 | 212·50 | 101 | 225·00 |
| 4 Barbus tor | 10 | 46·00 | 27 | 114·00 | 6 | 25·75 | 11 | 36·50 |
| 5 Barbus sarana and others | 1 | 0·50 | .. | .. | .. | .. | .. | .. |
| 6 Labeo kontius | 711 | 838·00 | 407 | 431·00 | 134 | 200·50 | 131 | 85·00 |
| 7 Labeo fimbriatus | 139 | 491·00 | 140 | 572·25 | 66 | 190·25 | 41 | 150·25 |
| 8 Labeo calbasu | 447 | 1,640·75 | 557 | 2,163·25 | 433 | 1,644·75 | 268 | 862·50 |
| 9 Labeo bata | 1,057 | 1,109·00 | 908 | 937·50 | 92 | 136·50 | 263 | 214·50 |
| 10 Labeo paral and others | 7 | 8·50 | .. | .. | .. | .. | .. | .. |
| 11 Wallago attu | 365 | 1,526·00 | 336 | 1,917·25 | 231 | 1,146·50 | 155 | 635·75 |
| 12 Mystus aor | 1,041 | 1,947·00 | 849 | 2,087·50 | 540 | 1,605·50 | 221 | 613·00 |
| 13 Catla catla | 29 | 535·50 | 49 | 879·75 | 81 | 1,347·75 | 39 | 529·75 |
| 14 Labeo rohita | 26 | 219·50 | 19 | 165·50 | 103 | 352·00 | 12 | 108·75 |
| 15 Cirrhina cirrhosa | 47 | 164·00 | 16 | 67·00 | 11 | 32·00 | 7 | 25·25 |
| 16 Cirrhina mrigala | 90 | 549·00 | 49 | 325·00 | 62 | 476·75 | 33 | 211·25 |
| 17 Eel | .. | .. | .. | .. | .. | .. | .. | .. |
| 18 Murrel | .. | .. | .. | .. | 1 | 3·00 | .. | .. |
| 19 Mirror carp | .. | .. | 1 | 8·00 | .. | .. | .. | .. |
| 20 Etroplus and others | 5 | 2·25 | .. | .. | .. | .. | .. | .. |
| Total .. | 5,354 | 10,976·75 | 4,670 | 11,524·00 | 2,400 | 8,038·50 | 1,981 | 4,473·25 |

* Water level in the reservoir.

| (1)—*cont.* | *September.* | | *October.* | | *November.* | | *December.* | | *Annual.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | * 915·75—914·37 | | 914·23—912·13 | | 914·30—913·75 | | 917·94—914·83 | | | |
| | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* | *Number.* | *Weight.* |
| | (18) | (19) | (20) | (21) | (22) | (23) | (24) | (25) | (26) | (27) |
| 1 Barbus dubius .. .. .. .. | 800 | 699·50 | 262 | 336·75 | 797 | 660·00 | 2,267 | 1,961·75 | 19,673 | 24,173·25 |
| 2 Barbus carnaticus .. .. .. .. | 43 | 36·00 | 16 | 21·00 | 29 | 28·75 | 26 | 21·50 | 684 | 633·00 |
| 3 Barbus hexagonalepis .. .. .. | 11 | 15·75 | 5 | 14·50 | 16 | 45·00 | 23 | 52·00 | 570 | 1,234·75 |
| 4 Barbus tor .. .. .. .. .. | 5 | 14·50 | 4 | 10·00 | 9 | 4·50 | 8 | 20·75 | 139 | 407·25 |
| 5 Barbus sarana and others .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 14 | 8·25 |
| 6 Labeo kontius .. .. .. .. | 88 | 69·25 | 27 | 19·75 | 102 | 68·25 | 263 | 212·00 | 3,063 | 3,090·00 |
| 7 Labeo fimbriatus .. .. .. .. | 67 | 228·00 | 8 | 27·25 | 8 | 31·00 | 47 | 205·25 | 859 | 3,115·00 |
| 8 Labeo calbasu .. .. .. .. | 199 | 480·50 | 50 | 99·50 | 112 | 280·75 | 207 | 562·50 | 3,213 | 11,274·50 |
| 9 Labeo bata .. .. .. .. .. | 146 | 105·25 | 70 | 56·50 | 343 | 243·25 | 1,363 | 1,042·75 | 5,776 | 5,258·75 |
| 10 Labeo paral and others .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 37 | 48·50 |
| 11 Wallego attu .. .. .. .. | 48 | 212·75 | 58 | 237·50 | 75 | 251·75 | 222 | 1,109·50 | 2,319 | 9,071·00 |
| 12 Mystus aor .. .. .. .. | 155 | 32·50 | 135 | 250·05 | 349 | 565·75 | 1,323 | 2,221·00 | 10,695 | 18,959·00 |
| 13 Catla catla .. .. .. .. .. | 12 | 217·25 | 4 | 79·50 | 47 | 315·00 | 183 | 837·75 | 587 | 7,374·50 |
| 14 Labeo rohita .. .. .. .. | 6 | 53·25 | .. | .. | 2 | 28·50 | 11 | 65·25 | 230 | 1,546·25 |
| 15 Cirrhina cirrhosa .. .. .. .. | 2 | 8·25 | .. | .. | 5 | 8·50 | 11 | 21·25 | 139 | 448·25 |
| 16 Cirrhina mrigala .. .. .. .. | 18 | 120·25 | 2 | 12·00 | 6 | 63·75 | 8 | 56·25 | 336 | 2,274·75 |
| 17 Eel .. .. .. .. .. | .. | .. | 3 | 00·50 | .. | .. | .. | .. | 44 | 21·25 |
| 18 Murrel .. .. .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 4 | 12·25 |
| 19 Mirror carp .. .. .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | 20·00 |
| 20 Etroplus and others .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 106 | 31·00 |
| Total .. | 1,636 | 2,301·50 | 744 | 1,165·25 | 1,900 | 2,594·75 | 5,962 | 8,389·50 | 48,500 | 89,001·50 |

* **Water level in the reservoir.**

TABLE 4 (*a*).

*Bhavanisagar fishing—Comparative results in th number and weight of fish landed in five nets with and without floats*$^{e}$ *in May* 1964.

| *Date.* | *Nets without floats and sinkers.* | | *Nets with floats and sinkers.* | |
|---|---|---|---|---|
| | *Number of fish.* | *Weight (in kgs.).* | *Number of fish.* | *Weight (in kgs.)* |
| (1) | (2) | (3) | (4) | (5) |
| 1st May 1964 .. .. .. .. .. .. | 27 | 59·50 | 137 | 248·25 |
| 2nd May 1964 .. .. .. .. .. .. | 54 | 104·00 | 220 | 374·00 |
| 3rd May 1964 .. .. .. .. .. .. | *No data.* | *No data.* | *No data.* | *No data.* |
| 4th May 1964 .. .. .. .. .. .. | 33 | 103·00 | 196 | 442·00 |
| 5th May 1964 .. .. .. .. .. .. | 56 | 103·50 | 222 | 404·00 |
| 6th May 1964 .. .. .. .. .. .. | 40 | 86·00 | 206 | 353·00 |
| 7th May 1964 .. .. .. .. .. .. | 20 | 55·00 | 274 | 252·00 |
| 8th May 1964 .. .. .. .. .. .. | 25 | 95·00 | 91 | 237·00 |
| 9th May 1964 .. .. .. .. .. .. | 41 | 104·00 | 133 | 296·00 |
| 10th May 1964 .. .. .. .. .. .. | 26 | 60·00 | 104 | 231·00 |
| 11th May 1964 .. .. .. .. .. .. | 45 | 93·00 | 179 | 311·00 |
| 12th May 1964 .. .. .. .. .. .. | 81 | 100·00 | 287 | 422·00 |
| 13th May 1964 .. .. .. .. .. .. | 48 | 94·00 | 367 | 338·00 |
| 14th May 1964 .. .. .. .. .. .. | 28 | 80·00 | .. | 369·00 |
| 15th May 1964 .. .. .. .. .. .. | 62 | 169·50 | 215 | 433·00 |
| 16th May 1964 .. .. .. .. .. .. | 58 | 108·00 | 198 | 408·00 |
| 17th May 1964 .. .. .. .. .. .. | 41 | 116·50 | 199 | 640·00 |
| 18th May 1964 .. .. .. .. .. .. | 43 | 162·00 | 204 | 584·00 |
| 19th May 1964 .. .. .. .. .. .. | 46 | 111·50 | 236 | 584·00 |
| 20th May 1964 .. .. .. .. .. .. | 41 | 92·00 | 198 | 378·00 |
| 21st May 1964 .. .. .. .. .. .. | 35 | 78·00 | 155 | 306·00 |
| 22nd May 1964 .. .. .. .. .. .. | 30 | 70·50 | 164 | 306·00 |
| 23rd May 1964 .. .. .. .. .. .. | 42 | 83·50 | 216 | 426·00 |
| 24th May 1964 .. .. .. .. .. .. | 55 | 99·25 | 265 | 505·00 |
| 25th May 1964 .. .. .. .. .. .. | 37 | 82·00 | 183 | 416·00 |
| 26th May 1964 .. .. .. .. .. .. | 43 | 68·60 | 125 | 217·00 |
| 27th May 1964 .. .. .. .. .. .. | 33 | 79·50 | 129 | 283·00 |
| 28th May 1964 .. .. .. .. .. .. | 30 | 60·00 | 122 | 233·00 |
| 29th May 1964 .. .. .. .. .. .. | *No data.* | *No data.* | *No data.* | *No data.* |
| 30th May 1964 .. .. .. .. .. .. | *No data.* | *No data.* | *No data.* | *No data.* |
| 31st May 1964 .. .. .. .. .. .. | 23 | 69·00 | 234 | 410·00 |
| Total .. | 1,143 | 2,586·25 | 5,259 | 10,301·25 |

### TABLE 4 (*b*).

*Bhavanisagar fishing—Comparative results in the number and weight of fish landed in five nets with and without floats in May 1964.*

| Date. | Without floats and frame. | | With floats and frame. | |
|---|---|---|---|---|
| | Number of fish. | Weight (in kgs.). | Number of fish. | Weight (in kgs. |
| (1) | (2) | (3) | (4) | (5) |
| 1st June 1964 .. .. | 70 | 180·00 | 268 | 579·00 |
| 2nd June 1964 .. .. | 53 | 131·00 | 222 | 550·00 |
| 3rd June 1964 .. .. | 62 | 181·00 | 172 | 457·00 |
| 4th June 1964 .. .. | 81 | 129·00 | 227 | 447·00 |
| 5th June 1964 .. .. | 47 | 129·00 | 205 | 437·00 |
| 6th June 1964 .. .. | | *No data.* | 129 | 238·00 |
| 7th June 1964 .. .. | | *No data.* | 74 | 150·00 |
| 8th June 1964 .. .. | | *No data.* | | |
| 9th June 1964 .. .. | | *No data.* | | |
| 10th June 1964 .. .. | 65 | 110·00 | 134 | 249·00 |
| 11th June 1964 .. .. | 61 | 294·00 | 187 | 666·00 |
| 12th June 1964 .. .. | 39 | 116·00 | 156 | 368·00 |
| 13th June 1964 .. .. | 34 | 126·00 | 112 | 335·00 |
| 14th June 1964 .. .. | 23 | 64·00 | 77 | 227·00 |
| 15th June 1964 .. .. | 22 | 88·00 | 100 | 309·00 |
| 16th June 1964 .. .. | 20 | 81·00 | 67 | 249·00 |
| 17th June 1964 .. .. | 42 | 122·00 | 183 | 453·00 |
| 18th June 1964 .. .. | 28 | 118·00 | 90 | 297·00 |
| 19th June 1964 .. .. | 42 | 122·00 | 190 | 470·00 |
| 20th June 1964 .. .. | 39 | 90·00 | 184 | 393·00 |
| 21st June 1964 .. .. | 47 | 111·00 | 193 | 505·00 |
| 22nd June 1964 .. .. | 45 | 93·00 | 161 | 380·00 |
| 23rd June 1964 .. .. | 38 | 89·00 | 200 | 368·00 |
| 24th June 1964 to 30th June 1964 | | *No data.* | | |
| Total .. | 858 | 2,374·00 | 3,271 | 8,127·00 |

## Table 5.

*Fishing in Bhavanisagar—Catch efficiency in relation to number of fish caught and mesh of the nets.*

| Date. | *Macrones aor.* | | | *Wallago attu.* | | | *Catla catla.* | | | *Labeo calbasu and L. fimbriatus.* | | | *Labeo bata.* | | | *Cirrhina mrigala Labeo rohita.* | | | *Labeo kontiu and B. dubius.* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *(mesh sizes.)* | | | *(mesh sizes.)* | | | *(mesh sizes.)* | | | *(mesh sizes.)* | | | *(mesh sizes.)* | | | *(mesh sizes.)* | | | *(mesh sizes.)* | | |
| | 2″ | 2½″ | 4″ | 2″ | 2½″ | 4″ | 2″ | 2½″ | 4″ | 2″ | 2½″ | 4″ | 2″ | 2½″ | 4″ | 2″ | 2½″ | 4″ | 2″ | 2½″ | 4″ |
| (1) | | (2) | | | (3) | | | (4) | | | (5) | | | (6) | | | (7) | | | (8) | |
| 15th May 1964 | .. | 28 | 4 | .. | 7 | 15 | .. | .. | 1 | .. | 3 | 18 | 48 | 7 | 8 | .. | 1 | 2 | 12 | 45 | .. |
| 16th May 1964 | .. | 16 | .. | .. | 3 | 4 | .. | .. | 1 | .. | 9 | 30 | 30 | 2 | .. | .. | .. | 6 | 15 | 81 | .. |
| 17th May 1964 | .. | 25 | 13 | .. | 3 | 11 | .. | .. | 5 | .. | 11 | 32 | 32 | 5 | .. | .. | 2 | 8 | 5 | 48 | .. |
| 18th May 1964 | .. | 31 | 2 | .. | 3 | 9 | .. | .. | 3 | .. | 6 | 21 | 25 | .. | .. | .. | .. | 3 | 15 | 52 | 14 |
| 19th May 1964 | .. | 32 | 8 | .. | 3 | 18 | .. | .. | 3 | .. | 5 | 28 | 41 | 2 | .. | .. | .. | 4 | 20 | 60 | 12 |
| 20th May 1964 | .. | 28 | 3 | .. | 3 | 6 | .. | .. | 1 | .. | 2 | 16 | 34 | .. | .. | .. | 2 | 5 | 5 | 81 | 11 |
| 21st May 1964 | 3 | 28 | 5 | .. | 2 | 6 | .. | .. | 1 | .. | 4 | 8 | .. | .. | .. | .. | 1 | 7 | 12 | 65 | 7 |

## TABLE 6.

*Bhavanisagar Fishing—Species and number of fish landed in low level condition (+844·96).*

Total Number of days fished.—6.

Total Units employed.—6.

Number of nets of each unit.—Catla (*a*) =10 × 50 metres.

(*b*) =5 × 65 metres.

Rangoon nets=5 × 35 metres.

| *Date.* | *Barbus dubius.* | | *Catla catla.* | | *Labeo rohita.* | | *Cirrhina mrigala.* | | *Wallagonia attu.* | | *Mystus aor and Mystus Seenghala.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| (1) | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) |
| 25th April 1964 .. .. | 22 | 31·50 | 18 | 292·00 | 3 | 35·00 | 13 | 92·00 | 10 | 59·00 | 37 | 92·00 |
| 26th April 1964 .. .. | 16 | 37·00 | 14 | 281·00 | 4 | 40·00 | 7 | 56·00 | 16 | 125·00 | 35 | 77·00 |
| 27th April 1964 .. .. | 31 | 35·00 | 6 | 101·00 | 5 | 60·00 | 6 | 43·00 | 12 | 33·00 | 60 | 92·50 |
| 28th April 1964 .. .. | 46 | 61·00 | 4 | 69·00 | 1 | 12·00 | 8 | 57·00 | 12 | 31·00 | 62 | 12·00 |
| 29th April 1964 .. .. | 61 | 59·00 | .. | .. | .. | .. | 1 | 4·00 | 12 | 32·50 | 64 | 109·50 |
| 30th April 1964 .. .. | 80 | 100·00 | 6 | 97·00 | 4 | 49·00 | 2 | 18·50 | 17 | 52·00 | 49 | 98·00 |

| (1)—*Cont.* | *Labeo ariza.* | | *Other Barbus species.* | | *Miscellaneous.* | | *Labeo kontius.* | | *Labeo calbasu.* | | *Labeo fimbriatus.* | | *Total.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| | | (8) | | (9) | | (10) | | (11) | | (12) | | (13) | | (14) |
| 25th April 1964 | 70 | 95·00 | 4 | 10·50 | 1 | 2·50 | 22 | 33·50 | 56 | 229·00 | 15 | 64·00 | 270 | 1,036·00 |
| 26th April 1964 | 56 | 64·00 | 2 | 5·00 | .. | .. | 10 | 17·00 | 65 | 239·00 | 8 | 31·00 | 233 | 972·00 |
| 27th April 1964 | 80 | 60·50 | 74 | 49·00 | 9 | 17·00 | 7 | 6·50 | 41 | 156·00 | 17 | 68·00 | 348 | 721·50 |
| 28th April 1964 | 122 | 91·00 | 29 | 55·00 | 5 | 13·00 | 14 | 13·00 | 42 | 160·50 | 20 | 78·50 | 365 | 753·00 |
| 29th April 1964 | 71 | 54·50 | 96 | 56·00 | .. | .. | .. | .. | 7 | 28·00 | 4 | 14·00 | 316 | 357·50 |
| 30th April 1964 | 46 | 32·00 | 42 | 32·00 | .. | .. | 20 | 14·50 | 23 | 84·00 | 2 | 5·50 | 291 | 582·50 |
| | | | | | | | | | | | | | 1,823 | 4,422·50 |

### TABLE 7.

*Bhavani sagar Fishing—Species and number of fish landed in F. R. L. (915+60) in the same place as Table 6—Area drained by Bhavanisagar.*

Rangoon nets=15×35 metres.

4" Catla nets=5×60 meters.

| *Date.* | | *Catla catla.* | | *Wallago attu.* | | *Labeo calbasu.* | | *Labeo ariza.* | | *Labeo rohita.* | | *Mystus aor and Mystus senghala.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| (1) | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | |
| 15th December 1964 | .. | 1 | 12·50 | 12 | 82·50 | 2 | 7·50 | 87 | 57·50 | .. | .. | 56 | 92·50 |
| 16th December 1964 | .. | 5 | 46·00 | 8 | 63·50 | 19 | 54·50 | 46 | 52·50 | .. | .. | 48 | 85·00 |
| 17th December 1964 | .. | 1 | 21·00 | 9 | 60·00 | 16 | 37·00 | 98 | 70·50 | .. | .. | 60 | 103·00 |
| 18th December 1964 | .. | 5 | 78·50 | 2 | 24·00 | 9 | 26·00 | 38 | 33·50 | .. | .. | 35 | 60·00 |
| 19th December 1964 | .. | 1 | 23·50 | 3 | 7·50 | 8 | 26·00 | 62 | 38·50 | .. | .. | 46 | 64·50 |
| 20th December 1964 | .. | 3 | 53·00 | 4 | 17·50 | 7 | 20·00 | 58 | 33·50 | 1 | 8·00 | 53 | 94·00 |
| 21st December 1964 | .. | 6 | 108·25 | 6 | 39·00 | 13 | 28·75 | 58 | 34·75 | .. | .. | 37 | 65·50 |

| (1)—*Cont.* | | *Barbus dubius.* | | *Other barbus species.* | | *Cirina mrigala.* | | *Labeo kontius.* | | *Labeo Fimbriatus.* | | *Tolal.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| | | (8) | | (9) | | (10) | | (11) | | (12) | | (13) | |
| 15th December 1964 | .. | 43 | 45·00 | 1 | 0·50 | 8 | 16·00 | 7 | 5·00 | 2 | 6·00 | 219 | 325·00 |
| 16th December 1964 | .. | 147 | 113·25 | .. | .. | .. | .. | 12 | 10·25 | 6 | 11·00 | 291 | 435·50 |
| 17th December 1964 | .. | 89 | 74·00 | .. | .. | 1 | 8·00 | 13 | 11·00 | 3 | 10·50 | 290 | 395·00 |
| 18th December 1964 | .. | 60 | 47·00 | .. | .. | .. | .. | 10 | 9·25 | .. | .. | 159 | 278·25 |
| 19th December 1964 | .. | 67 | 54·00 | .. | .. | .. | .. | 24 | 17·75 | .. | .. | 211 | 231·75 |
| 20th December 1964 | .. | 138 | 130·50 | 2 | 2·75 | .. | .. | 13 | 12·75 | .. | .. | 279 | 345·00 |
| 21st December 1964 | .. | 135 | 126·50 | 14 | 10·75 | 1 | 6·50 | 13 | 9·50 | .. | .. | 283 | 429·00 |
| | | | | | | | | | | Total | .. | 1,732 | 2,439·50 |

TABLE 8.

*Bhavanisagar fishing—Species and number of fish landed under 916 level—Area drained by Moyar.*

| Date. | *Barbus dubius.* | | *Mystus aor.* | | *Wallago attu.* | | *Labeo calbasu.* | | *Labeo ariza.* | | *Labeo fimbriatus.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| (1) | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | |
| 1st January 1965 .. .. | 38 | 31·25 | 42 | 56·75 | 9 | 17·50 | 26 | 51·50 | 16 | 10·00 | 2 | 6·00 |
| 2nd January 1965 .. .. | 26 | 27·75 | 31 | 45·00 | 1 | 5·00 | 15 | 35·00 | 8 | 6·00 | .. | .. |
| 3rd January 1965 .. .. | 52 | 53·00 | 35 | .. | 2 | 10·00 | 6 | 13·00 | 2 | 5·50 | .. | .. |
| 4th January 1965 .. .. | 73 | 73·00 | 30 | 45·25 | 4 | 8·00 | 6 | 14·00 | 21 | 16·00 | .. | .. |
| 5th January 1695 .. .. | 59 | 73·50 | 14 | 39·25 | 2 | 6·25 | 10 | 34·00 | 42 | 32·00 | .. | .. |
| 6th January 1965 .. .. | 50 | 53·00 | 35 | 73·75 | 8 | 10·50 | 3 | 9·00 | 31 | 23·50 | .. | .. |

| (1)—*Cont.* | *Cirrhina mrigala.* | | *Labeo rohita.* | | *Catla catla.* | | *Labeo kontius.* | | *Other barbus species.* | | *Miscellaneous.* | | *Total.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* | *No.* | *Weight.* |
| | (8) | | (9) | | (10) | | (11) | | (12) | | (13) | | (14) | |
| 1st January 1965 | .. | .. | — | — | 8 | 6·25 | 1 | 1·00 | 1 | 2·15 | 123 | 163·00 | 266 | 343·50 |
| 2nd January 1965 | .. | .. | .. | .. | 6 | 4·00 | 1 | 0·50 | .. | .. | 89 | 124·50 | 176 | 247·75 |
| 3rd January 1965 | 1 | 1·75 | .. | .. | 6 | 600 | 2 | 1·75 | 2 | 4·00 | 108 | 155·25 | 215 | 250.25 |
| 4th January 1965 | .. | .. | .. | .. | 4 | 3·50 | 2 | 1·50 | .. | .. | 140 | 161·25 | 280 | 322·50 |
| 5th January 1965 | 1 | 5·75 | .. | .. | 1 | 1·25 | 2 | 2·50 | 1 | 4·50 | 132 | 199·00 | 264 | 398·00 |
| 6th January 1965 | .. | .. | .. | .. | 5 | 9·00 | .. | .. | .. | ... | 132 | 183·75 | 264 | 371·00 |
| | | | | | | | | | | | Total | .. | 1,465 | 1,933·00 |

# A STUDY OF THE QUALITY OF DRIED WHITE BAITS IN THE TRADE

BY

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## Introduction

About 30,000 to 40,000 tonnes of white baits (Anchoviella sp.) are landed annualy in India, forming about 2·5 to 4 per cent of the total fish landings in the country. They occur in shoals from June to January every year (Devanesan and Chidambaram, 1953) and is mostly concentrated on the coasts of Kerala, Madras and Andhra States. White baits are highly valued in Ceylon, Burma and other South East Asian countries and most of the landings in our country are simply dried on the beach and exported to these countries. Approximately about 7,000 to 10,000 tonnes of dried spratts (white baits) are being exported annually from the Tuticorin port and this variety alone accounts for nearly 60 per cent of the total exports of dried fish from this port. However the quality of the dried white baits in the trade is in general found to be far from satisfactory, chiefly due to heavy admixture of sand and improper drying. It is very essential to prescribe and maintin certain standards of quality for the dried spratts (white baits), to retain the existing export markets and also to capture new markets. The Indian Standards Institution has taken up the work of drafting specifications for this dried fish product and has entrusted the work to the Fisheries Technological Station, Tuticorin. In the course of this work, a study of the quality of the dried spratts (white baits) in the trade was done by the present authors and the results of this study are embodied in this paper.

## Materials and methods

The trade samples of dried spratts (white baits) were collected from the various dried fish godowns at Tuticorin and from the Fish Curing Yards in Kanyakumari district and the history of each sample, i.e., the place and date of catch and the methods of processing were ascertained from the fishermen and fish merchants. The samples were immediately examined for their size (length and breadth) and count per 100 gm. and organoleptic characteristics like moisture, sodium chloride and acid insoluble ash were also estimated in each sample according to A.O.A.C. methods of analysis (1945). The T.V.N. was also determined by Conway's Method (1947).

With a view to find out the scope for improving the quality of the product, dried white baits were also prepared by the authors from fresh white baits after thorough washing in clean sea water and drying the fish on palmyrah mats in the sun. The drying was also tried on the beach sand as practised by the fishermen to know the effect of washing only. The products so obtained were also tested as detailed above for their organoleptic and chemical characteristics and compared with the trade samples.

### *Results*

The results of analysis of 80 samples of dried white baits from the trade are shown in Table I. A study of the table would reveal the following:—

*Size.*—The length of the dried white baits ranged from 4·3 to 7·3 cms. and breadth from 0·57 to 1·3 cms. 76 per cent of the trade samples were of 6·0 to 7·0 cms. group, 14 per cent were of 5 to 6 cms. group, 8 per cent were above 7 cms. in length and 2 per cent were below 5 cms.

*Count.*—For grading purpose, the trade samples were also examined by counting the number of dried white baits in 100 gms. of each sample. The counts ranged from 74 to 396/100 gm. 95 per cent of the samples had counts below 200 and may be classified as large size. Five per cent had counts about 200 and may be graded as small.

*Organoleptic characteristics.*—About 70 per cent of the trade samples had good or normal light grey appearance. Only about 8 per cent of the samples were soft in texture, the rest being hard or medium hard. Flavour was poor in 16 percent of the samples and in 34 per cent of the samples, the odour was ammoniacal or pungent. Surface moisture was also noticed in 34 per cent of the samples. Only about 7·5 per cent of the trade samples had fungal attack.

*Chemical characteristics.*—The maximum and minimum ranges and the percentage of trade samples found in each range group of the various chemical characteristics like moisture, NaCl, acid insolubles and T.V.N. are summarised below :—

MOISTURE.

*Minimum*—11·3 per cent. *Maximum*—31·01 per cent.

| *Range groups.* | *Per cent of trade samples.* |
|---|---|
| Below 10 per cent .. | Nil. |
| 10·1 to 15·0 per cent .. | 21·96 |
| 15·1 to 20·0 per cent .. | 47·56 |
| 20·1 to 25·0 per cent .. | 18·29 |
| Above 25 per cent .. | 12·19 |

SODIUM CHLORIDE.

*Minimum*—0·34 per cent. *Maximum*—3·66 per cent.

| *Range groups.* | *Per cent of trade samples.* |
|---|---|
| Below 1 per cent .. .. | 14·63 |
| 1·1 to 2 per cent .. | 57·32 |
| More than 2 per cent .. | 28·05 |

ACID INSOLUBLES.

*Minimum*—4·3 per cent. *Maximum*—29·58 per cent.

| *Range groups.* | *Per cent of trade samples.* |
|---|---|
| Below 7 per cent | 12·20 |
| 7·1 to 10·0 per cent | 18·29 |
| 10·1 to 12·0 per cent | 17·07 |
| 12·1 to 15·0 per cent | 26·83 |
| 15·1 to 20·0 per cent | 14·63 |
| Above 20 per cent | 10·98 |

T.V.N. MG/100GM.

*Minimum*—64. *Maximum*—840.

| *Range groups.* | PER CENT. |
|---|---|
| Less than 20 | 45·5 |
| Between 200 and 300 | 31·03 |
| Above 300 | 23·47 |

The results of analysis of the samples prepared by the authors are shown in Table II. By washing the fish in clean sea water and drying on beach sand as practised in the trade, the acid insolubles were found to be 5·73 per cent and this could be brought down to 2·54 per cent by drying the fish on mats. The moisture ranged from 13·53 to 14·45 per cent and the T.V.N. from 32·0 to 54·0 mg./100 gm. The products were very attractive in appearance and had fresh flavour and good odour.

**Discussions**

George (1958) has described seven species of anchoviella (white baits) recorded from Indian waters. Out of these 3 species, namely, Anchoviella indica, A. Commersoni and A. tri. are known to be of commercial importance. The white baits are extensively sun-dried as this kind of curing seems to have a better effect on the taste of this fish. Only rarely in the rainy weather in Kerala State, they are salted. The present method of preparation of dried white baits in the trade consists of simply drying the fish catches in the sun on the beach sand without any washing or addition of salt for a day or two and then packing the dried fish in palmyrah mats in bundles of one Cwt. capacity. As the transactions are by weight the tendency in the trade is to pack the products without sufficient drying. It is also held by the trade that much dried products result in breakage of the whole fish and the product losses its market value. As much as 78·04 per cent of the trade samples had moisture above 15 per cent and 30·48 per cent of the samples had moisture above 20 per cent. This high percentage of moisture in the unsalted dried white baits accounts for its present low storage life. It may be possible to improve the shelf life of the product considerably if the product is dried to 15 per cent moisture level. In such perfect dried products, a good portion of the adhering sand particles may also fall off, yielding a product of better quality. It has however to be studied how far this dryage will increase the breakage and the optimum moisture level has to be worked out with reference to least breakage and maximum shelf life possible. Further studies are in progress in this direction.

The chief defect in the product is heavy admixture of sand during the drying process. The Acid insolubles ranged from 4·3 to 29·58 per cent in the trade samples. Only 12·2 per cent the trade samples contained acid insolubles less than 7 per cent and 69·51 per cent of the samples had more than 10 per cent of acid insolubles. As stated by Krishna Pillai et. al. (1956) this condition is due to the present unsatisfactory method of drying on open beach wherein a good amount of sand is blown into the product by wind. By properly washing the fish in clean sea water and by drying the fish over mats, the authors showed that the acid insolubles could be brought down to as low as 2·54 per cent. The trade would do well and produce better quality products by drying the fish over palmyrah mats on raised platforms instead of on beach sand.

No salt is added at present in the preparation of the product and the salt content varied from 0·34 per cent to 3·66 per cent in the trade samples. The absence of salt coupled with high moisture content account for low storage life of the product which becomes dark in colour and crumbles to pieceswith in a month. Venkataraman and Vasavan (1959) have shown that samples of salted white bait remained in good condition for two months without any attack of " red " or moulds. In fact salting of white baits is resorted to in Kerala State in wet weather and Venkataraman and Vasavan (1956) suggested a proportion of one part of salt for six parts of fish for salt curing medium sized white baits for best quality products.

In sun-dried fish products, the T. V. N. was found to vary from 50 to 300 mg./100 gm. of the product by Pillai. et. al. (1956). In our study, the T.V.N. of dried white baits in the trade ranged from 64 to 560 mg./100 gm. According to Venkataraman and Vasavan (1959), samples of salted fish in the initial stages of spoilage had a T.V.Ns. value of 200 mg./100 gm. From this standard only 45·5 per cent of the trade samples of dried white baits can be said to have not spoiled.

## *Summary.*

A study of the quality of the dried white baits in the trade was done in view of the commercial importance of the product in the export as well as internal markets. The product is prepared by merely drying the whole fish on the beach, without any addition of salt. A good portion of the trade samples ranged in length from 6 cms. to 7 cms. had 'Counts' of below 200/100 gm. and can be classified as " Large size ." The rest of the samples which had 'Counts' above 200/100 gm. may be graded as " small ". About 70 per cent of the trade samples were normal in appearance, 8 per cent of the samples soft in texture, 34 per cent of the samples ammociacal or pungent in odour and 7·5 per cent of the samples had fungal attack. Moisture ranged from 11 · 3 per cent to 31·01 per cent and 78·04 per cent of the trade samples had moisture above 15 per cent, this high percentage of moisture probably

accounting for the low storage life of this unsalted product. Another chief defect in the product was found to be heavy admixture of sand, the acid insolubles ranging from 4·3 to 29·58 per cent in the trade samples, 77·80 per cent of which had acid insolubles more than 7 per cent. Experiments by the authors showed that the acid insolubles could be brought down to 2·54 per cent by properly cleaning the fish in clean sea water and by drying the fish over palmyrah mats.

*Acknowledgments.*

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TABLE I.

*Showing the analytical data of dried white baits in the Trade.*

| Serial number and place of catch. | Method of drying. | Average size. |  | Count per 100 gm. | Appearance. | Texture. | Flavour. | Odour. | Surface Moisture. | Fungal attack. | H2 per cent. | Moisture free basis. |  |  | T.V.N mg./ 100 gm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Length in cm. | Breadth in cm. |  |  |  |  |  |  |  |  | Nacl. per cent. | Acid Insol. per cent. |  |  |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |  | (15) |
| 1 Thanjavur district .. | Dried without salt in open beach. | 6·8 | 1·1 | 134 | Normal. | Hard. | Fresh. | Fresh cured. | Dry. | Nil. | 14·63 | 1·63 | 11·69 |  | 64 |
| 2 Pondicherry .. .. | Do. | 6·1 | 0·7 | 148 | Do. | Do. | Good | Pungent | Do. | Do. | 12·8 | 0·97 | 12·28 |  | 208 |
| 3 Thanjavur district .. | Do. | 4·3 | 0·57 | 396 | Do. | Do. | Fair | Fresh. | Do. | Do. | 13·46 | 1·68 | 12·81 |  | 64 |
| 4 Do. .. .. | Do. | 5·4 | 0·8 | 228 | Do. | Do. | Good. | Do. | Do. | Do. | 13·8 | 1·84 | 14·86 |  | 80 |
| 5 Do. .. .. | Do. | 6·1 | 1·0 | 154 | Do. | Med. Hard | Do. | Do. | Sl. moist | Do. | 18·32 | 1·22 | 22·45 |  | 120 |
| 6 Kanyakumari district. | Do. | 6·4 | 1·1 | 140 | Do. | Hard. | Do. | Pungent | Dry | Do. | 13·6 | 1·2 | 13·4 |  | 220 |
| 7 Do. .. .. | Do. | 5·5 | 0·9 | 138 | Do. | Do. | Do. | Fresh. | Do. | Do. | 14·28 | 0·96 | 12·44 |  | 72 |
| 8 Do. .. .. | Do. | 6·4 | 1·0 | 136 | Do. | Do. | Do. | Do. | Do. | Do. | 15·4 | 0·7 | 8·59 |  | 64 |
| 9 Thanjavur district .. | Do. | 6·0 | 1·0 | 164 | Do. | Do. | Do. | Do. | Do. | Do. | 13·47 | 0·34 | 14·96 |  | 96 |
| 10 Do. .. .. | Do. | 5·8 | 1·0 | 170 | Do. | Do. | Do. | Do. | Do. | Do. | 13·49 | 0·95 | 11·04 |  | 120 |
| 11 Do. .. .. | Do. | 6·4 | 1·1 | 144 | Do. | Do. | Do. | Do. | Do. | Do. | 14·46 | 0·93 | 16·4 |  | 112 |
| 12 Pondicherry .. .. | Do. | 5·3 | 0·9 | 238 | Do. | Do. | Do. | Do. | Do. | Do. | 11·36 | 2·19 | 7·73 |  | 144 |
| 13 Thanjavur district .. | Do. | 6·4 | 1·0 | 164 | Do. | Do. | Do. | Do. | Do. | Do. | 11·94 | 1·12 | 7·4 |  | 156 |
| 14 Kanyakumari district | Do. | 6·7 | 1·0 | 94 | Do. | Med.Hard | Do. | Fair | Do. | Do. | 14·91 | 1·24 | 11·11 |  | 200 |
| 15 Do. .. .. | Do. | 6·8 | 1·1 | 106 | Do. | Do. | Do. | Do. | Do. | Do. | 14·62 | 1·10 | 12·4 |  | 176 |
| 16 Do. .. .. | Do. | 6·1 | 0·9 | 152 | Do. | Do. | Do. | Fresh | Do. | Do. | 14·65 | 0·9 | 10·8 |  | 144 |
| 17 Thanjavur district.. | Do. | 5·9 | 1·1 | 160 | Do. | Do. | Do. | Sl. moist. | Sl.moist. | Do. | 18·36 | 1·78 | 11·87 |  | 256 |
| 18 Do. .. .. | Do. | 6·2 | 1·0 | 138 | Do. | Do. | Do. | Fresh | Do. | Do. | 19·25 | 1·55 | 4·56 |  | 324 |
| 19 Do. .. .. | Do. | 6·4 | 1·0 | 135 | Do. | Do. | Do. | Good | Do. | Do. | 17·53 | 1·6 | 7·7 |  | 238 |
| 20 Do. .. .. | Do. | 6·5 | 1·1 | 136 | Dark | Sl. soft. | Fair | Fair | Do. | Do. | 11·73 | 0·66 | 24·51 |  | 186 |
| 21 Do. .. .. | Do. | 7·2 | 1·2 | 108 | Normal | Med.Hard. | Fresh | Good | Dry | Do. | 11·34 | 0·68 | 7·28 |  | 256 |
| 22 Kanyakumari district. | Do. | 6·6 | 1·1 | 132 | Do. | Hard | Do. | Do. | Do. | Do. | 15·87 | 1·00 | 8·77 |  | 372 |
| 23 Do. .. .. | Do. | 7·2 | 1·2 | 74 | Do. | Do. | Do. | Do | Do. | Do. | 15·78 | 1·25 | 7·88 |  | 164 |
| 24 Do. .. .. | Do. | 6·8 | 1·3 | 100 | Grey | Do. | Good | Do. | Do. | Do. | 15·16 | 1·1 | 12·82 |  | 230 |
| 25 Do. .. .. | Do. | 6·0 | 1·2 | 100 | Normal | Sl.soft | Do. | Do. | Sl.soft. | Do. | 23·81 | 1·13 | 10·9 |  | 164 |
| 26 Do. .. .. | Do. | 5·4 | 1·1 | 160 | Do. | Med. hard. | Fresh | Do. | Do. | Do. | 18·33 | 1·43 | 14·71 |  | 240 |
| 27 Do. .. .. | Do. | 7·1 | 1·1 | 110 | Do. | Do. | Do. | Do. | Do. | Do. | 18·96 | 1·28 | 9·09 |  | 320 |
| 28 Do. .. .. | Do. | 6·6 | 0·9 | 130 | Normal | Med. Hard. | Good | Good | Dry | Do. | 16·05 | 1·42 | 10·0 |  | .. |
| 29 Do. .. .. | Do. | 6·8 | 1·1 | 115 | Do. | Hard | Fresh | Do. | Do. | Do. | 15·98 | 0·79 | 7·19 |  | .. |
| 30 Do. .. .. | Do. | 6·6 | 1·2 | 128 | Grey | Do. | Do. | Do. | Do. | Do. | 15·74 | 1·34 | 11·77 |  | .. |
| 31 Do. .. .. | Do. | 6·2 | 1·1 | 138 | Ash | Med. hard. | Do. | Do. | Sl. moist. | Do. | 17·25 | 1·22 | 16·56 |  | .. |
| 32 Do. .. .. | Do. | 6·3 | 1·1 | 128 | Normal | Hard | Do. | Do. | Dry | Do. | 12·35 | 1·29 | 15·85 |  | .. |
| 33 Do. .. .. | Do. | 6·6 | 1·1 | 128 | Do. | Med. hard. | Do. | Fair | Sl. moist. | Do. | 19·38 | 1·26 | 5·45 |  | .. |
| 34 Do. .. .. | Do. | 6·5 | 1·0 | 140 | Grey | Hard | Do. | Good | Dry | Do. | 16·62 | 1·39 | 8·87 |  | .. |
| 35 Do. .. .. | Do. | 6·5 | 1·1 | 128 | Normal | Med. hard. | Do. | Fair | Sl. moist. | Do. | 22·74 | 1·35 | 4·93 |  | .. |
| 36 Do. .. .. | Do. | 6·5 | 1·1 | 126 | Do. | Do. | Fair | Do. | Do. | Do. | 22·55 | 1·48 | 14·5 |  | .. |
| 37 Do. .. .. | Do. | 6·4 | 1·1 | 130 | Do. | Do. | Fresh | Good | Moist | Do. | 20·76 | 1·09 | 12·28 |  | .. |
| 38 Do. .. .. | Do. | 6·2 | 1·1 | 140 | Do. | Hard | Do. | Do. | Dry | Do. | 15·98 | 1·38 | 7·35 |  | .. |
| 39 Do. .. .. | Do. | 6·6 | 0·9 | 130 | Grey | Med. hard. | Do. | Do. | Sl. moist. | Do. | 17·49 | 1·84 | 10·15 |  | .. |
| 40 Do. .. .. | Do. | 6·2 | 1·1 | 138 | Normal | Hard | Do. | Do. | Do. | Do. | 16·46 | 1·43 | 13·46 |  | .. |
| 41 Do. .. .. | Do. | 6·5 | 1·0 | 140 | Ash grey | Med. hard. | Good | Good | Do. | Do. | 18·25 | 0·72 | 6·9 |  | .. |
| 42 Do. .. .. | Do. | 6·5 | 1·1 | 136 | Normal | Do. | Fresh | Do. | Do. | Do. | 19·08 | 1·09 | 13·93 |  | .. |
| 43 Do. .. .. | Do. | 6·0 | 1·2 | 140 | Gray | Do. | Do. | Do. | Do. | Do. | 16·52 | 1·47 | 20·15 |  | .. |
| 44 Do. .. .. | Do. | 6·8 | 1·3 | 100 | Ash grey | Do. | Do. | Do. | Moist | Do. | 21·37 | 1·65 | 11·61 |  | .. |
| 45 Do. .. .. | Do. | 6·5 | 1·1 | 136 | Grey | Do. | Do. | Do. | Do. | Do. | 19·17 | 0·82 | 4·76 |  | .. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | Do. | Do. | 6·4 | 1·1 | 145 | Normal | Do. | Good | Good | Sl. moist. | Do. | 18·9 | 1·8 | 7·78 | .. |
| 47 | Do. | Do. | 6·7 | 1·1 | 94 | Grey | Do. | Fresh | Do. | Do. | Do. | 19·15 | 2·08 | 10·15 | .. |
| 48 | Do. | Do. | 6·1 | 0·9 | 148 | Normal | Do. | Do. | Do. | Do. | Do. | 19·15 | 0·95 | 15·43 | .. |
| 49 | Do. | Do. | .. | .. | 136 | Poor | Hard | Poor | Ammoniacal. | Do. | Do. | 24·52 | 2·91 | 17·12 | 315 |
| 50 | Do. | Do. | .. | .. | 128 | Fair | Do. | Fair | Fresh | Dried. | Do. | 13·13 | 2·91 | 18·78 | 210 |
| 51 | Do. | Do. | .. | .. | 100 | Poor | Do. | Good | Ammoniacal. | Do. | Do. | 30·99 | 3·66 | 10·44 | 266 |
| 52 | Do. | Do. | .. | .. | 96 | Good | Do. | Do. | Fresh | Do. | Do. | 30·73 | 2·81 | 20·45 | 133 |
| 53 | Do. | Do. | .. | .. | 122 | Poor | Med. hard | Poor | Ammoniacal. | Do. | Do. | 25·77 | 3·16 | 15·26 | 245 |
| 54 | Do. | Do. | .. | .. | 98 | Good | Do. | Fair | Sl. Ammoniacal. | Do. | Do. | 27·44 | 2·89 | 29·58 | 189 |
| 55 | Do. | Do. | .. | .. | 85 | Fair | Do. | Do. | Do. | Do. | Do. | 24·76 | 1·47 | 10·49 | 105 |
| 56 | Do. | Do. | .. | .. | 105 | Good. | Do. | Do. | Do. | Do. | Do. | 29·60 | 2·17 | 6·58 | 70 |
| 57 | Do. | Do. | .. | .. | 130 | Poor | Soft | Poor | Putrid | Do. | Do. | 31·01 | 1·8 | 11·83 | 224 |
| 58 | Do. | Do. | .. | .. | 100 | Fair | Med. hard. | Fair | Strongly ammoniacal. | Do. | Do. | 17·41 | 1·85 | 22.38 | 840 |
| 59 | Do. | Do. | .. | .. | 142 | Poor | Hard | Poor | Putrid | Do. | Do. | 15·29 | 1·99 | 12·69 | 210 |
| 60 | Do. | Do. | .. | .. | 130 | Good | Med. hard. | Good | Fresh dried. | Do. | Do. | 15·44 | 2·21 | 12·21 | 140 |
| 61 | Do. | Do. | .. | .. | 175 | Poor | Hard. | Poor. | Ammoniacal. | Nil. | Nil. | 16·60 | 2·32 | 12·31 | 560 |
| 62 | Do. | Do. | .. | .. | 74 | Do. | Med. hard | Fair. | Putrid. | Do. | Do. | 16·70 | 1·87 | 10·70 | 420 |
| 63 | Do. | Do. | .. | .. | 150 | Do. | Soft | Poor. | Stinking. | Present. | Do. | 15·32 | 2·37 | 9·72 | 490 |
| 64 | Do. | Do. | .. | .. | 108 | V. Poor | Med. hard. | Do. | Do. | Do. | Do. | 21·54 | 2·10 | 16·09 | 700 |
| 65 | Do. | Do. | .. | .. | 146 | Fair. | Hard. | Do. | Ammoniacal. | Nil. | Do. | 18·18 | 2·05 | 14·81 | 350 |
| 66 | Do. | Do. | .. | .. | 142 | Do. | Do. | Fair. | Stinking. | Do. | Do. | 16·89 | 2·08 | 14·55 | 175 |
| 67 | Do. | Do. | .. | .. | 124 | V. Poor. | Soft. | Poor. | Ammoniacal. | Do. | Do. | 20·96 | 1·94 | 18·91 | 420 |
| 68 | Do. | Do. | .. | .. | 147 | Poor. | Med. hard. | Do. | Do. | Slight. | Sl. | 24·19 | 2·11 | 23·16 | 280 |
| 69 | Do. | Do. | .. | .. | 128 | Do. | Soft. | Do. | Strongly ammoniacal. | Present. | Nil. | 34·08 | 1·97 | 20·69 | 210 |
| 70 | Do. | Do. | .. | .. | 152 | Fair. | Hard. | Do. | Ammoniacal. | Nil. | Do. | 17·79 | 2·36 | 13·92 | 315 |
| 71 | Do. | Do. | .. | .. | 340 | Poor. | Do. | Do. | Do. | Do. | Do. | 21·35 | 2·29 | 19·53 | 175 |
| 72 | Mangalore | Do. | .. | .. | 142 | Fair. | Do. | Fair. | Sl. ammoniacal. | Do. | Do. | 25·02 | 2·02 | 22·03 | 140 |
| 73 | Trivandrum | Do. | .. | .. | 132 | Do. | Do. | Do. | Do. | Do. | Do. | 17·61 | 2·63 | 7·62 | 280 |
| 74 | Kanyakumari district. | Do. | .. | .. | 133 | Good. | Do. | Do. | Do. | Do. | Sl. | 18·42 | 1·87 | 5·73 | 210 |
| 75 | Alleppey | Do. | .. | .. | 115 | Do. | Do. | Good. | Fresh dried. | Do. | Nil. | 21·98 | 2·52 | 12·32 | 140 |
| 76 | Trivandrum | Do. | .. | .. | 135 | Do. | Do. | Fair. | Sl. ammoniacal. | Do. | Sl. | 22·90 | 2·52 | 17·30 | 105 |
| 77 | Do. | Do. | .. | .. | 132 | Do. | Do. | Good. | Do. | Do. | Do. | 24·06 | 2·60 | 14·96 | 350 |
| 78 | Kanyakumari district. | Do. | .. | .. | 160 | Do. | Med. Hard. | Fair | Ammoniacal. | Do | Nil. | 19·04 | 1·63 | 6·88 | 210 |
| 79 | Do. | Do. | .. | .. | 150 | Fair. | Hard. | Fair. | Do. | Do. | Present. | 18·46 | 1·83 | 12·82 | 315 |
| 80 | Do. | Do. | .. | .. | 155 | Do. | Med. hard. | Fair. | Sl. ammoniacal. | Do. | Do. | 26·74 | 1·89 | 27·70 | 175 |

## TABLE II.

*Showing the analytical data of dried white baits prepared.*

| *Experiment number.* | *Place of catch.* | *Particulars.* | *Average in size.* | | *Count. per 100 gm.* | *Appearance.* | *Texture.* | *Flavour.* | *Odour.* | *Surface moisture.* | *Fungal attack.* | *Moisture.* | *H2° free basis.* | | *TV.B. (N) mg./100 gm.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Length. in cm.* | *Breadth. in cm.* | | | | | | | | | *Nacl.* | *Acid. insol.* | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| 1 | Kanyakumari district. | Dried on the mat without salt. | 5·7 | 1·0 | 174 | Fresh grey. | Hard | Fresh | Good | Dry | Nil. | 14·45 | 1·95 | 2·54 | 32·0 |
| 2 | Do. .. | Dried on the sand without salt. | 6·4 | 1·0 | 152 | Ash grey. | Do. | Do. | Do. | Do. | Do. | 13·53 | 1·18 | 5·73 | 54·0 |

# THE EFFECT OF EPIPHYTIC ALGAE ON THE CARBON ASSIMILATION BY NAJAS GRAMINEA DEL

BY

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It was frequently noticed that aquatic plants, especially *Najas graminea Del.*, that were growing in cisterns had some slimy substances, on the surface of the leaf, stem, etc. These slimy substances occurred in a dense clump completely covering the leaf surface. A slow and regular death rate was observed many times in the experimental cisterns kept in this Research Station. The colour of those slimy material changed gradually from white to Brown. The slimy materials were examined under Miscroscope and indentified as forms belonging to *Chlorophyceae*, *Cynophyceae* and *Bacillariophyceae*.

It was believed that the epiphytic algae that occur on *Najas graminea Del*[1] have a retrading effect on the carbon assimilation of that plant and thereby ultimately leading to the death of the plant slowly. The following forms were found to occur on the leaves and stem of *Najas graminea Del*:—

*Cyanophyceae*—

1 *Oscillatoria Limosa* Ag. ex. Gamont.
2 *O. subbrevis schmidte.*
3 *Nostoc carneum* Ag. (Geitler).
4 *Crucigenia aniculata* (Lemn.) schm.
5 *Microcystis ramosa*—Bhardw.
6 *Merismopedia tenuissima* Lonm.
7 *Anabena orientalis* Dixit.
8 *Nostoc punctiformae* (Kutz) var popularum (Geitler).
9 *Phormidium ambiguum* Gomont.
10 *Schizothrix friesii* (Ag.) com.
11 *Rhaphidiopsis curvata* Fritsch and Rich.

*Chlorophycese*—

12 *Chloroccoccum humicola* Rab.
13 *Closterium lunnula* (Mull) Nitzsch.
14 *Cosmarium subhumidum* Nordst.
15 *Oedogonium humidulum* Kutz.

*Becillariophyceae*—

16 *Cymbelia hustedtti* Krasske.
17 *Navicula simplex* Krasske.
18 *Comphonema apiculatum* Ehr.
19 *Pinnularia viridis* (Nitz.) Ehr.

Carbon assimilations experiments[2] were conducted in the field, so as to find out whether the epiphytic algae have any effect on that vital process. The experiments were all begun at 9·30 a.m. and stopped at 4·0 p.m. Both the Experimental and control funnel-tubes were placed in the same cistern only 3 to 4 cms. apart. The specimens were carefully selected, regarding their age, etc. All variables such as mineral content of the water, pH and light were same for both the experimental and control. The experimental plants had epiphytic algae on their leaf, stem, etc. The volume of plants taken for all experiments was 5 c.c.

The results of the experiments are given in Table I to show the effect of epiphytic algae in carbon assimilation.

TABLE I.

*Evolution of oxygen in carbon assimilation.*

| *Number and date.* (1) | *Control c.c.* (2) | *Experimental c.c.* (3) | *Difference D.* (4) | $D^2$. (5) | *Differences in percentage.* (6) |
|---|---|---|---|---|---|
| 1 30th October 1964 | 1·9 | 0·9 | 1·00 | 100 | 111·11 |
| 2 31st October 1964 | 1·3 | 1·0 | 0·3 | 9 | 30·00 |
| 3 Do. | 1·3 | 0·5 | 0·8 | 64 | 160.00 |
| 4 6th November 1964 | 0·9 | 0·3 | 0·6 | 36 | 200·00 |
| 5 12th November 1964 | 2·5 | 1·8 | 0·7 | 49 | 38.88 |
| 6 16th November 1964 | 2·0 | 1·4 | 0·6 | 36 | 42·85 |
| 7 17th November 1964 | 1·0 | 0·5 | 0·5 | 25 | 100·00 |
| 8 Do. | 1·0 | 0·4 | 0·6 | 36 | 150·00 |
| 9 18te November 1964 | 2·0 | 1·0 | 1·0 | 100 | 100·00 |
| 10 Do. | 2·0 | 0·9 | 1·1 | 100 | 122·22 |
|  | 159 | 87 | 72 | 555 |  |
| Average/Mean | 15·9 | 8·7 | 7·2 | 55·5 |  |

[2] Average increase in control 105·50 per cent.

---

[1] Standard deviation :

| | | |
|---|---|---|
| Observed mean difference | | 7·2 |
| d at 0·05 level | .. 2·262 x ·092 .. | ·208 |
| d at 0·01 level | .. 3·250 x ·092 .. | ·299 |

As the value of the two critical differences at both 0·05 and 0·01 are much lower than the observed mean difference (7·2), the result is significant, namely, the plants with epiphytic algae on them produce less of oxygen than those without them. In other words, the epiphytic algae have a retarding effect on the carbon assimilation of *Najas garminea Del.*

The authors thanks are due to Mr. John Chandra Mohan, M.Sc., the Assistant Agronomist, Bhavanisagar, for his help in statistical calculations.

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# CHANOS CULTURE AT THE BRACKISHWATER FISH FARM, ADYAR

BY

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## Introduction

Studies on Chanos chanos Forskal in India have been made under various aspects. Chacko (1955) has given us information on the spawning of Chanos and in 1942 has recorded his studies on the rearing of the larvae. Panikkar, Tampi and Viswanathan (1952) have made studies on the fry. The food and feeding habits have been dealt with by Chacko (1945), (1949) and Tampi (1958). Studies on growth have been made by Chidambaram and Unny (1946) and Chacko (1948). Raj (1931), Devanesan and Chacko (1944) and Chacko and Mahadevan (1955) have been interested in the culture of Chanos, while details of acclimatisation, transport and culture in inland waters have been worked out by Job and Chacko (1947), Ranganathan and Ganapathi (1949), Ganapati, Chacko, Srinivasan and Krishnamurthi (1950), Ganapati and Alikunhi (1952) and Menon, Srinivasan and Krishnamurti (1959). Malupillai and Chacko (1956)and Tampi (1960) have touched on the aspects of Chanos farming in marine fish farms and saline swamps.

Stray references have been made on the growth of Chanos in brackishwater ponds by Chacko and Mahadevan (1955) and Menon, Srinivasan and Krishnamurti (1959) but details of farming in brackishwater in India are not known. This work on the farming of Chanos chanos has been done in the specially constructed brackishwater fish farm at Adyar, which is the first of its kind in the Madras State and was constructed under the II Five-Year Plan.

## Description of farm

The farm (*see* Sketch) is 55·4 acres in extent. A reservoir 36 acres in area has been formed by the construction of a regulator across the narrowest portion of the Adyar Creek, a furlong above its confluence with the Adyar river. The creek joins the Adyar river at its Northern flank, just as it enters the Bay of Bengal. The regulator consists of three pairs of screw gearing shutters, one of each pair being perforated to be used only when water is required and escape of impounded fish is to be prevented. The judicious operation of these shutters during tidal ingress and egress facilitates the entrapping of shoals of marine fish, mostly in the juvenile stages, which enter with the tides in search of pasture.

A series of nurseries, rearing ponds, stock ponds and marketing ponds covering an area of 19·4 acres are situated on the southern bank of the reservoir. They get their supply of water either directly or indirectly from the reservoir. The nurseries are four in number, 50 ft. by 25 ft. in dimension and maintain a foot and a half of water in summer and three feet of water during the monsoons. There are three rearing ponds each 10 cents in extent which maintain the same depth of water as the nurseries. Lying parallel to the reservoir, quite close to the regulator are three pairs of stock ponds, S1, S2, S3, S4, S5, and S6 respectively, each 120 feet by 100 feet in dimensions maintaining three to six feet of water. Three of them S1, S3 and S5 are directly in connection with the reservoir, each of them being provided with a small shutter that can be lifted up to allow entry of fish and water. As the shutter is perforated it can be kept closed to prevent escape of fish, without in any way preventing entry of water. Of the three pairs, S1 is connected with S2 by a shutter, while S4 and S6 get their supply from the Marketing pond S8 which in turn gets its supply from the reservoir, S8 is 8 acres in extent and leads on to Marketing pond S7 which has no other connection. S7 is 5 acres in extent. 3 to 6 feet of water is maintained it the Marketing ponds also, depending on the season of the year.

All connections with the reservoir are cut off during the summer months when the bar is closed and drought conditions prevail due to intense evaporation. The water level is then at its lowest.

High water level is maintained during the monsoons when freshwater floods from the river not only pervade the sea but also enter the reservoir. High levels are also maintained during the high tides of the post monsoon period.

## Observations

1. *Availability of fry*—Four and a half years records show that there have always been two peak periods of availability of Chanos fry at Adyar. There is a major peak period in summer and a minor peak period during the monsoons. Fry of sizes ranging from 14 mms. to 40. mms. can be collected during these periods.

In summer the bar is usually closed. Fry have invariably been collected in the months of May and July although there have been instances where they have been available as early as April, sometimes in June and even as late as August in spite of the bar being closed.

This year fry of size 14 mms. to 21 mms. were first collected on 25th April 1963. It was interesting to note that the bar which was closed for summer, temporarily opened up on 22nd April 1963 the night of new moon and remained so for a few days. The opening up was caused by the action of the high breakers usually common during new moon. There were showers on the 21st, 23rd and 24th April 1963.

The monsoon period collection always begins in October and fry have been recorded as late as December. The bar is usually open during this period. Fry of Chanos are detected just after showers when flood waters recede, exposing innumerable shallow puddles of water along the Adyar estuary and creek. These puddles are found teeming with millions of Chanos fry which can be collected with little effort using coarse rectangular pieces of cloth or nets of velon screen also rectangular in shape. There is practically no mortality during these operations except when the fry have been kept over long in the tin carriers without change of water or when they have been overcrowded in the containers. Death occurs as a result of rise in temperature and depletion of oxygen.

Following collection the fry are best transferred to happas or very small enclosures made in the nursery ponds where they must be protected from birds (usually King fishers and herons,) snakes (usually *Cerebrus rhyncops* and predatory fish (especially *Therapon jarbua*). The depth of water to be maintained is from 15 cms. to 23 cms. There must be a good supply of natural food such as plankton and algal encrustations if growth is to be rapid. Artificial food may be resorted to in the absence of natural food. A week or two after, depending on the successful growth of the fry they may be given entrance into the deeper waters of the nursery varying in depth from 30 cms.to 46 cms. Here they will be exposed to a wider area, greater pressure of water and greater possibilities of attacks by enemies and they wil have to be stronger and more active to withstand these dangers. Experiment showed that while barely 3 per cent of fry survived when introduced directly into a nursery of dimensions 50 feet by 25 feet by 2 feet, 71 per cent survived when the above precautions were taken.

2. *Food of Chanos.*—The food of Chanos at various sizes in the farm was found to be as follows :—

(*a*) 25 *mms. to* 100 *mms.*—This group could be further divided into two size ranges on the strength of their feeding habits, i.e.,

(1) 25 *mms.* to 40 *mms.*—

| | |
|---|---|
| Zoo organisms— | |
| Brachionus | P |
| Copepods | P |
| Notholca | F |
| *Phyto organisms*— | |
| Oscillatoria | P |
| Navicula | F |
| Gyrosigma | F |
| Debris | P |
| Sand grains | F |

(2) 41 *mms. to* 100 *mms.*—

Stomach contents had a fine orange, yellow or orangish yellow colour—

| | |
|---|---|
| Zoo organisms— | |
| Brachionus | P |
| Copepods | P |
| Copepod eggs | P |
| Nauplii | P |
| Peridinium | P |
| Nematodes | F |
| Gastropod post larvae | F |
| Phyto organisms— | |
| Oscillatoria | P |
| Microcystis | P |
| Spirulina | C |
| Enteromorpha | C |
| Chaetomorpha | C |
| Gyrosigma | S |
| Navicula | C |
| Fragillaria | C |
| Thalassiosira | C |
| Guinardia flaccida. | C |
| Debris | F |
| Sand grains | F |

(*b*) 101 *mms. to* 200 *mms.*—

Zoo organisms—

| | |
|---|---|
| Brachionus | C |
| Copepods | C |
| Copepod eggs | P |
| Nauplii | C |
| Peridinium | S |
| Gastropod post larvae. | F |
| Foraminifera | F |

Phyto organisms—

| | |
|---|---|
| Oscillatoria | P |
| Microcystis | C |
| Enteromorpha | C |
| Chaetomorpha | C |
| Navicula | P |
| Thalassiosira | P |
| Rhizosolenium | F |
| Suriella | F |
| Diploneis | F |
| Amphora | F |
| Debris | F |
| Sand grains | P |

(*c*) 201 *mms. to* 300 *mms.*—

Zoo organisms—

| | |
|---|---|
| Nauplii | C |
| Peridinium | C |

Phyto organisms—

| | |
|---|---|
| Gyrosigma | C |
| Navicula | C |
| Thalassiosira | P |
| Nitzschia closterium. | C |
| Nitzschia closterium var levidensis. | P |
| Debris | C |
| Sand grains | C |

(*d*) 301 *mms. to* 400 *mms.*—

Zoo organism—Nil.

Phyto organisms—

| | |
|---|---|
| Anabaena | C |
| Merismopedia | C |
| Navicula | C |
| Coscinodiscus | F |
| Tabellaria | F |

(*e*) 401 *mms. to* 500 *mms.*—

Gut contents slimy and whitish. Empty in most cases.

Zoo organisms—

| | |
|---|---|
| Peridinium | C |
| Nematodes | F |

Phyto organisms—

| | |
|---|---|
| Anabaena | C |
| Navicula | C |
| Gyrosigma | C |

The fry of Chanos feed voraciously and this voracity continues up to the 300 mm. stage when it dwindles. In the 401 mm. to 500 mm. size group many were found with empty stomachs.

"F" indicates—Few.
"C" indicates—Common.
"P" Indicates—Abundant.
"S" indicates—Swarms.

3. *Growth.*—(*a*) *Fry and fingerlings.*—Growth of fry under natural conditions was compared with the growth of those in the nurseries of the farm. Fry and fingerlings of size range 24 mm. to 74 mm. stocked in a nursery grew to a size range of 70 mm. to 82 mm. in one month and eighteen days. Fry of 21 mms. to 38 mms. size range in the estuary were found to have grown to a size range of 65 mms. to 90 mms. in one month and four days, which was decidedly better than that under artificial conditions.

(*b*) *Juveniles.*—Growth of young Chanos, just passed the fingerling stage, which is the best stock size, was studied in the stock ponds of the fish farm. Water spread of these ponds was nearly a sixth of an acre. Tables appended show the observations made.

Tables 1 and 2 show the growth of Chanos in stock ponds one and two. Stock pond one (S1) lies adjacent to the reservoir and receives its supply of water directly from the reservoir. Stock pond two (S2) which lies parallel to S1 and further away from the reservoir gets its supply from S1.

Two hundred and fifty Chanos of sizes ranging from 40 mms. to 125 mms. were stocked in S1 and S2 on 15th December 1959. Owing to the disparity in the size of the fish stocked, the same disparity was noticed throughout the period of investigation. The trend in the growth was similar in both ponds but growth was all along better in S2 which gets only an indirect supply of water from the reservoir through S1.

Planktological and hydrographical investigations were made in S1 and S2 during the same period to observe how growth was correlated with these factors. Tables 3 to 9 give an idea of the phyto and zoo-planktonic organisms occuring in the various months in 1960 and 1961 and their relative abundance. A greater variety of zoo-plankton is observed in S2 although Copepods and Nauplii are more abundant in S1. Phytoplankton is definitely more varied and more abundant in S2.

Slight but definite differences exist in the hydrographical conditions of the two ponds. Tables 10 and 11 show the meteorological conditions in the various months and tables 12 to 15 show the hydrographical conditions in S1 and S2 in 1960 and 1961. Salinity is higher in S2 from July to December 1960 whereas it is higher, or equal in S1 from January 1960 to June 1960. Satinity range in 10·15% to 36·2% in $S^1$ and 16·2% to 37·93% in $S^2$, Surface temperature is always equal or higher in S2, rarely less. Oxygen values are always 4.06 cc/L and over, even as high as 5·76 cc/L in S1 in April. In S2 they have been found to be as low as 3·10, 3·57 and 3·08 cc/L in the months of April, June and September but it has been as high as 5·57 cc/L in May 1960.

Silicate contents have been higher in S2 from January to July 1960 except in April 1960 when it was equal to that of S1. From August onwards the value has been alternatively higher in each pond starting with S1.

The months when the water has been very clear are September, October, November and December and S2 has all along shown the greater clarity during these months. The months of high turbidity are from March to July and in these months up to June the waters of S2 are more turbid.

Ph is as high as 8·7 in both ponds from January to March. It goes down to 8·4 in both ponds in April and remains so till July in S1 but fluctuates between 8·0 and 8·2 in S 2. In August there is a big drop to 7·4 in S1 but this drop occurs in the next month in S2 to the value of 7·2. S2 remains at 7·6 after this till December whereas it fluctuates between 7·6 and 7·8 in S1.

The disparity is size of the Chanos stocked ranged over a difference of 85 mm. both in S1 and S2 at the time of stocking. This difference was found to increase to 130 mm. in S1 and 75 mm. in S2 in one year.

Graphs 1 and 3 and Tables 1 and 2 show that growth in length steadily increases in both S1 and S2 from December 1959 to May 1960 in S1 and December 1959 to June 1960 in S2. After this growth is poor and continues to remain so till January 1961 in S1 and December 1960 in S2. The maximum length attained in five months time in S1 is 33·3 cm. or 1'1" nearly and the maximum length attained in S2 in the same period is 34·7 cm. or 1' 1·7"nearly, which increases to 40·2 cm. or 1' 3·9" nearly in the space of a month.

Graphs 2 and 3A also show the increase in weight in S1 and S2. In S1 there is a gradual increase in weight till May 1960 parallelling the increase in length. June and July show a stagnation in growth both in weight and length after which there is a shooting up in August. After August there seems to be no increase in weight or length till January 1961. There is a similar direct relationship in the increase in weight and length in S2. Till April the increase is gradual after which there is a steep rise till June both in weight and length. After June the increase in weight is not as rapid although it is steadily on the increase whereas the increase in length is very slight till August and then is imperceptible till December. The weight attained in five months in S1, is 225 grams or ½lb. nearly, while in S2 it is 360 grams or ¾ lb. nearly. A weight of 515 grams or a little over 1 lb. is reached in S2 in six months.

It was observed that longer fish very often weighed less than shorter ones. For a period of 6 months the fish in S1 were smaller than those in S2 by a maximum length of 6·9 cm. or 2·7" and a weight of half a pound. June to December is seen to be the common period of poor growth in both ponds.

The maximum length reached in S1 for one year is 39·5 cm. or 1' 3·6" nearly and that in S2, 43 cm. or 1'5" nearly. The maximum weight reached in S1, is 470 grams or a little more than 1 lb. and that in S2, 650 grams or 1¼ lbs.

Growth is resumed in December, 1960 but it is not as quick as the first six months of life in the stock ponds. The second year of life is more a growth in weight than in length. The maximum length reached in 1 year 9 months in S1 was 47·9 cm. or 1' 6·9" and in S2, 50·0 cm. or 1' 11·2". The maximum weight reached in S1, for the same period is 800 grams or 1¾ lbs. nearly and for S2, 1300 grams or 2¾ lbs. nearly. Again, in the second year the major growth is noticed up to June. The maxumim length reached in 3 years is not much more but the weight increases to 2 Kilo grams.

After a year and two months nearly a peculiar phenomenon was noticed in both ponds. The fish which were 380 cm. or 1¼ feet in size and more, and which weighed 454 grams or 1 pound and more were found to jump wildly in the water dashing their heads against the sides of the ponds and injurying themselves so that they died. The dead specimens when examined revealed wounds on the snout and head. The adipose eyelids and the membrane covering the snout was opaque, swollen and spongy. The stomach and guts were practically empty with whitish slimy matter in which no food material could be identified except stray Navicula occuring singly.

A good portion of the Chanos were disposed at this stage leaving a small number for further study. About 40 per cent of the numbers of the Chanos put in were lost due to natural causes. The remaining 60 per cent were harvested resulting in an output of approximately 450 Kilogrammes or 900 lb. of Chanos per acre per annum at a stocking rate of 1,500 seed per acre.

Several other stocking experiments were conducted and the observations recorded. (*a*) On 17th June 1960 Chanos fry of size range 10 mm. to 45 mm. size range were stocked at the rate 400 and 500 respectively in S1 and S2. 100 per cent mortality was recorded. (*b*) On 29th October 1960, 500 Chanos and Megalops fry of size range 15 mm to 85 mm were stocked in S1. 100 per cent mortality was recorded.

(*c*) On 17th February 1961, Chanos fingerlings of 82 mm. to 135 mm. and 62 mm. to 125 mm. size range were stocked in S1 and S2. respectively at the rate of 200 and 100 numbers. The larger sizes were put into S1 which exhibited poorer growth in the first experiment. Half the number only were put into S2 to see whether this difference would create an outstanding increase in the growth rate.

Results as seen in Table 16 show that larger fish naturally grow bigger first and so by stocking bigger fish in a pond with a poor growth rate, sizes obtained at harvest time can be expected to be similar to that in the pond with a better growth rate. Further, dimunition in numbers stocked has a limit 200 and 100 numbers stocked have not given better results than 250 stocked. There has been a wastage of area and food which would have been profitably utilised if more had been put in.

Tables 3—15 on Plankotology and Hydrography, of S1 and S2 in 1960, 1961 show that environmental conditions vary from year to year and hence the corresponding variations in growth from year to year. However growth in both ponds in 9 months is about a foot in length and over ¾ pound in weight.

(*d*) 2,850 Chanos fry of size range 30 mm. to 45 mm. were stocked in S3 and 4,350 Chanos fingerlings of size 60 mm. to 85 mm. were stocked in S5 on 1st June 1960.

Both ponds are similar in having direct connection with the reservoir and taking their water supply from it as they lie side by side, adjacent to the reservoir. The planktological and hydrographical conditions of these two ponds as seen from tables vary.

100 per cent mortality was recorded in S3 into which fry were stocked and 90 per cent mortality was recorded in S5 which though stocked with fingerlings was over stocked. The rate of growth of the remaining 10 per cent, i.e., 435 fish in S5 was very poor in spite of half of them being removed in the seventh and eighth months. Table 5 shows their growth. Maximum length reached in one year is 29·7 cm. or 11·5″ and maximum weight reached 150 grams or about $\frac{1}{3}$ lb. 100 of those removed on 23rd February 1961 were stocked in S3 but no improvement in the growth rate was found. Table 6 gives the growth recorded.

4. *Combination Cultures.*—Etroplus suratensis of size range 50 mm. to 165 mm. was cultured with Chanos in the ratio of 1 : 3 in S2, the pond which showed better growth. Growth of chanos was equally good in both the ponds S1 and S2 in the first quarter.This may be due to the introduction of Etroplus suratensis which is a bottom feeder as are the young stages of Chanos, but for which growth may have been better in S2 even at the very beginning.

Etroplus was found to breed in the ninth month and had migrated to S1 in the eleventh month from which 1,500 fry were collected for supply to inland waters. This indicated that the combination was a profitable concern.

Stocks of prawn larvae were found to naturally ascend the two ponds S1 and S2 and formed an attractive fishery. Penaeus indicus which formed the major prawn fishery was found to attain a maximum size of 18·1 cm. or 7 inches in March, three months after stocking of Chanos. 25 prawns of this size weighed a pound. Such sizes were available continuously after every second or third month during the growth of Chanos in the course of the year making it profitable especially as the growth of Chanos was in no way affected by its presence or its bottom feeding habit. Penaeus carinatus were also found in small numbers. They attained a size of 24·7 cm. or 9·5 inches in 3 to 4 months with a weight of a pound for 5 prawns put together.

## Discussion

Ganapathi and Chacko (1950) state that fish productivity of a pond depends on its size and nourishing power. Several other factors also play an important part in the yield of fish. Collection of seeds in the larval stages is more economical in that more seeds can be transported in a lesser number of containers and with a far lesser mortality rate than the collection of fingerlings. Experiments show that care has to be taken in the rearing of the larvae and fry so that here again, the survival rate may be high and growth may be as good as it would be in the natural environments.

The most suitable size for transference from the nurseries to the stock ponds is the fingerling stage, i.e., 80 mm. and over. Fry are lost in the wide and deep waters of the stock ponds. Fish stock of more or less the same size may preferably be stocked together as disparity in sizes during stocking continues to the time of harvesting, inconveniencing the harvesting of full grown as the undersized have to be retained for sale at a later date when they have sufficiently grown. The Chinese sieving method may be resorted to to segregate the Chanos fry just after the collection of the Chanos larvae and fry so that the different sizes may be reared in separate nurseries and then stocked separately, thereby eliminating this difficulty.

The collection of Chanos fry for stocking is inevitable as Chanos, unlike other marine species such as Mugil spp. Elops indicus, Chaetoessus nasus, Engraulis purava, Leiognathus sp. Therapon jarbua, Penaeus indicus and such others, was not found to ascend the brackish water ponds in appreciable numbers naturally, even though the larvae were always collected four to eight furlongs up the river and creek and never near the sea mouth, from where they are supposed to enter the estuary from the sea. One has therefore to concentrate on the periods of availability of the larvae to ensure an adequate supply of seeds for the year without which the Chanos crop would be a failure. The availability of larvae in summer even after the bar is closed gives ample food for thought. The possibilities are that the larvae enter the estuary via the Buckingham canal but this is ruled out by the fact that even when the canal was closed on the Madras side, due to repairs and when the bar at the Vellar estuary and the Cooum estuary were closed larvae were available. Granting that the canal was open it would not be possible for the delicate larvae to negotiate such deep waters. The temporary opening of the bar observed this year in April during New Moon time when Chanos larvae were also collected suggest two other possibilities. Either the breakers are so high during New moon, which is the usual spawning period, that eggs and larvae are washed over by the waves and carried by the force of the high tides as far up the river as possible or else temporary connections between the sea and estuary are formed when the larvae enter with the tides for a short spell, the connections closing up as quickly and unnoticed as they opened. Observation shows that the appearance of Chanos larvae varies slightly from year to year depending on the preceding rainfall. Malu Pillai and Chacko (1956) have also recorded this. There are however two distinct periods at Adyar which is very advantageous in that two collection periods will facilitate two stocking programmes during the year and enable a dual harvest per annum. Growth studies show that there is good growth in length and weight during the first five or six months after the fingerlings stage after which progress is slow. By the eight or ninth month a marketable size of approximately 1′3″ or 37·5 cm. in length and $\frac{3}{4}$ th pound or 375 grams in weight is reached when they can be disposed and a new stock of fingerlings introduced. Disposal will be possible even in the sixth month after stocking provided there is a good feeding programme as the results obtained in the growth studies made, are from unaided natural conditions when a foot has been attained in six months with a weight of half a pound, at which stage itself they are marketable.

Menon, Srinivasan and Krishnamurti (1952) and Chacko and Mahadevan (1954) also report that growth of Chanos in the first six months is rapid, slowing down in the next six. Studies at Adyar show that this is so independent of whether they are the October collection stocked in December or the April collection stocked in June. The fingerling stage of 80 mm. and over is reached in the space of two months and this is the best time for stocking if the mortality rate is to be low. Experiments show the large scale mortality incurred by stocking in the fry stage.

Overstocking also is found to result in a very high mortality rate. 250 fingerlings stocked in an area of a sixth of an acre has given the best results. The number could be increased to 500 and not over with satisfactory results depending on food supply and congenial hydrographical factors.

The food organisms taken in by the fish at various size is similar to that recorded by Chacko (1949), Esquerra (1951) and Tampi (1958) who attribute to it a browsing mode of feeding. It is however not selective and feeds on whatever is available either at the bottom or in the plankton and hence its fairly good growth with very little attention. The feeding phase is between the 41 mm. and 300 mm. stage and hence the good growth during the first six months after stocking. Tampi (1958) reports fish over 300 mm. with only a white mass of mucoid substance in the guts. This was noticed in fish of length 400 mm. to 500 mm. at Adyar. Their gonads were undifferentiated. They exhibited a strange phenomenon of madly jumping about probably in an urge to find a means of return to the sea for breeding. Tampi 1958 has also recorded specimens of 500 mm. from the sea with the sex differentiated which shows that they are large enough at this stage to attain sexual maturity. Immature specimens of the same size with empty stomachs have also been recorded from the sea.

Extraneous fish were found to enter into the Chanos ponds in the larval stages but it was not found advisable to grow them with the Chanos except for the prawns Penaeus indicus and Penaeus carinatus which formed a valuable source of food and income without detriment to the culture of Chanos. Food concurrents such as Mugil species and predators such as *Therapon jarbua* and *Elops indicus* had, as suggested by Schuster 1952, to be eradicated if sufficient food and space was to be maintained for the optimum growth of Chanos.

*Etroplus suratensis* when introduced in the proportion of 1 : 3 did not appreciably reduce the growth of Chanos and was welcome as a source of ready seed for supply to inland waters.

The general conclusions that may be drawn from the studies made, point to the fact that variations occur in hydrographical conditions from pond to pond of the same farm thereby altering the productivity also. This indicates that variations from farm to farm can normally be expected and suitable adjustments must be made to suit the particular piece of water to be farmed so that the maximum yield can be ensured. The growth of Chanos though it may not be as good as it is in fresh water is better than that recorded in a saline environment by Tampi (1960). There is ample scope for the culture of Chanos in Brackish water farms which can serve as storehouses for Chanos seed to be supplied to inland waters and form reservoirs of tasty and cheap fish food supply to the public at intervals of six months. A pre-planned programme of collection, nursing, rearing, stocking and harvesting together with favourable environmental conditions is necessary to achieve the goal.

## *Acknowledgment.*

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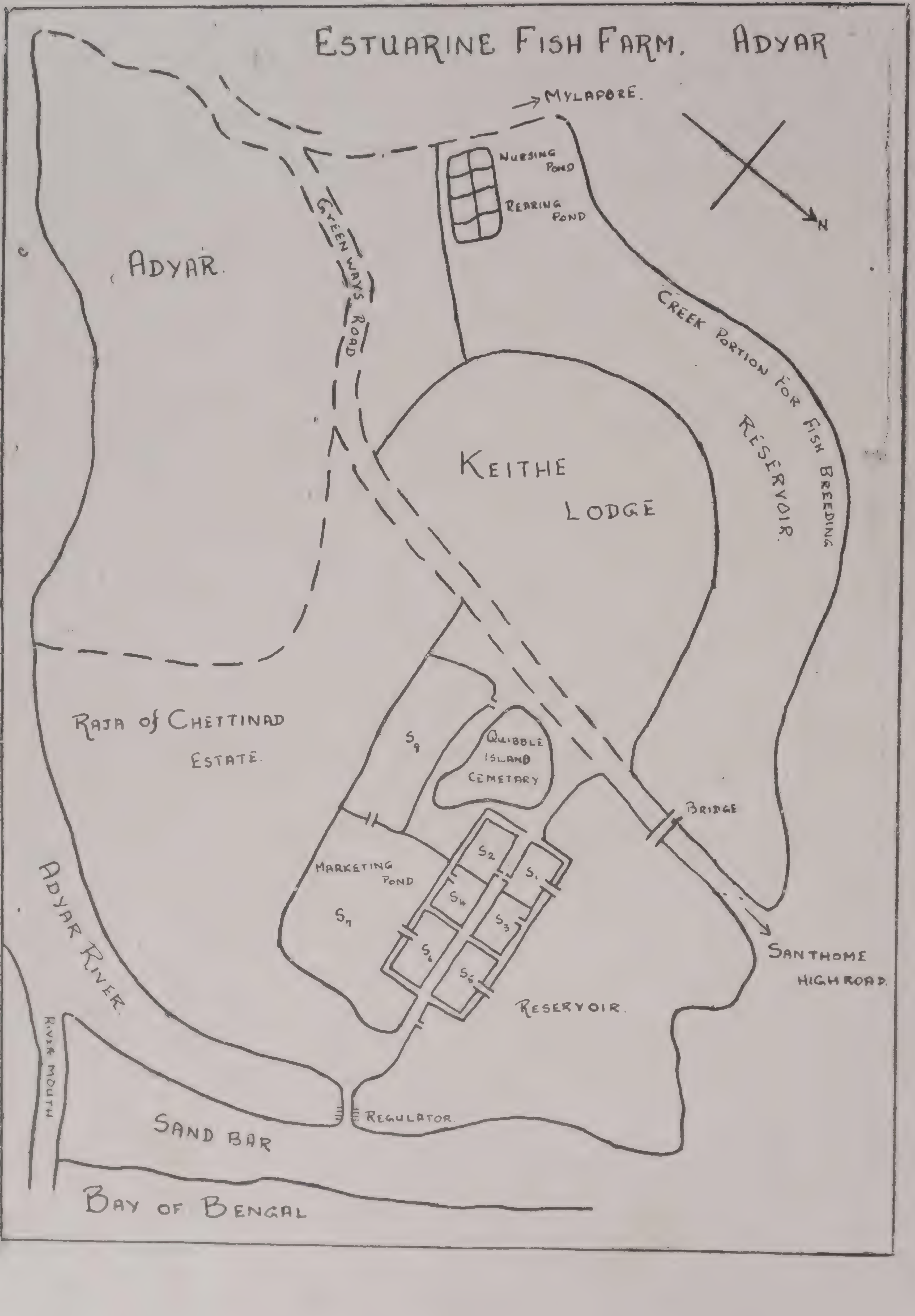
ESTUARINE FISH FARM. ADYAR
MYLAPORE.
N
NURSING POND
REARING POND
ADYAR.
GREEN WAYS ROAD
CREEK PORTION FOR FISH BREEDING
RESERVOIR.
KEITHE LODGE
RAJA of CHETTINAD ESTATE.
$S_8$
QUIBBLE ISLAND CEMETARY
BRIDGE
MARKETING POND
$S_7$
$S_2$
$S_1$
$S_4$
$S_3$
$S_6$
$S_5$
SANTHOME HIGH ROAD.
RESERVOIR.
ADYAR RIVER.
RIVER MOUTH
SAND BAR
REGULATOR.
BAY OF BENGAL

## TABLE 1.

*Growth Studies of Chanos chanos.*

Numbers stocked—250. In S.1. Date of stocking—15th December 1959.

| *Date of Trial netting.* | *Size Range in m.m.* | | *Weight Range in Grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 15th December 1959 | 40 | 125 | 1·2 | 2·4 |
| 24th February 1960 | 155 | 192 | 32 | 63 |
| 16th March 1960 | 175 | 203 | 44 | 65 |
| 21st April 1960 | 200 | 271 | 75 | 190 |
| 25th May 1960 | 240 | 333 | 115 | 226 |
| 28th June 1960 | 269 | 320 | 100 | 225 |
| 23rd July 1960 | 222 | 318 | 155 | 225 |
| 11th August 1960 | 210 | 375 | 150 | 375 |
| 22nd September 1960 | 268 | 356 | 175 | 240 |
| 29th November 1960 | High water—not available. | | | |
| 17th December 1960 | 340 | 395 | 280 | 470 |
| 30th January 1961 | 265 | 385 | 350 | 455 |
| 4th February 1961 | 337 | 466 | 325 | 600 |
| 5th February 1961 | Chanos dying. Disposed by sale. | | | |
| 24th March 1961 | Ten left for observation. | | | |
| 25th March 1961 | 372 | .. | 395 | .. |
| 22nd April 1961 | Not available. | | | |
| 29th May 1961 | 431 | 477 | 610 | 800 |
| 27th June 1961 | 433 | 479 | 660 | 750 |
| 15th July 1961 | 470 | .. | 750 | .. |
| 19th August 1961 | 436 | .. | 620 | .. |
| 16th September 1961 | 440 | .. | 640 | .. |

## TABLE 2.

*Growth Studies of Chanos chanos.*

Numbers stocked—250. In S. 2. Date of stocking—15th December 1959.

| *Date of Trial netting.* | *Size Range in m.m.* | | *Weight Range in Grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 15th December 1959 | 40 | 125 | 1·2 | 2·4 |
| 24th February 1960 | 110 | 191 | 24 | 72 |
| 16th March 1960 | 188 | 233 | 69 | 105 |
| 21st April 1960 | 245 | 270 | 115 | 170 |
| 25th May 1960 | 278 | 347 | 150 | 360 |
| 28th June 1960 | 275 | 402 | 185 | 515 |
| 23rd July 1960 | 305 | 415 | 280 | 560 |
| 11th August 1960 | 287 | 425 | 250 | 575 |
| 22nd September 1960 | 343 | .. | .. | 345 |
| 31st October 1960 | 395 | 428 | .. | 600 |
| 29th November 1960 | 335 | 352 | 275 | 345 |
| 17th December 1960 | 426 | 430 | 535 | 650 |
| 30th January 1961 | 372 | 455 | 375 | 700 |
| 4th February 1961 | 382 | 502 | 450 | 700 |
| | Chanos dying—Partly disposed. | | | |
| 25th March 1961 | 355 | 590 | 350 | 490 |
| 22nd April 1961 | 392 | 480 | 410 | 705 |
| 29th May 1961 | 426 | 492 | 600 | 840 |
| 27th June 1961 | 450 | 492 | 650 | 800 |
| 15th July 1961 | 440 | 460 | 620 | 730 |
| 19th August 1961 | 450 | 513 | 680 | 1,300 |
| 16th September 1961 | 430 | 465 | 650 | 1,000 |

TABLE 3.

*Plankton 1960 S1 Numbers per cc.*

| (1) | *April.*<br>(2) | *May.*<br>(3) | *June.*<br>(4) | *July.*<br>(5) | *August.*<br>(6) | *September.*<br>(7) | *October.*<br>(8) | *November.*<br>(9) | *Decem ber*<br>(10) |
|---|---|---|---|---|---|---|---|---|---|
| *Zoo plankton—* | | | | | | | | | |
| 1 Rotifer | .. | .. | .. | .. | .. | 720 | .. | .. | .. |
| 2 Insect larvæ | .. | .. | .. | .. | .. | .. | .. | Rare. | .. |
| 3 Nauplii | 60,476 | 20,210 | 4,474 | 824 | 3,805 | 6,108 | 1,680 | 180 | 1,440 |
| 4 Copepod | 194,399 | 847,163 | 3,986 | 470 | 2,435 | 2,378 | 780 | 120 | 6,710 |
| 5 Lepadid | 181 | 15 | 14 | 10 | 1 | 1 | 1 | 2 | 4 |
| 6 Medusæ | 178 | 6 | 3 | 20 | 25 | 55 | 3 | .. | 3 |
| 7 Mesopodopsis | 5 | Rare. | 1 | 18 | 1 | 54 | 90 | 39 | Rare |
| 8 Cypris | .. | .. | .. | .. | .. | .. | 85 | .. | .. |
| 9 Wing scale of dipteran | .. | .. | .. | .. | .. | .. | .. | Rare. | .. |
| 10 Lucifer | 17 | 1 | 1 | .. | .. | .. | .. | .. | .. |
| 11 Argulid | 1 | .. | 1 | 1 | 1 | .. | .. | .. | .. |
| 12 Sagitta | 153 | 325 | 6 | 10 | 5 | .. | .. | .. | .. |
| 13 Fish Larvæ | .. | 1 | .. | .. | 3 | .. | Rare. | Rare. | Rare |
| 14 Fish Eggs | 16 | 1 | 6 | 3 | 6 | 4 | 25 | .. | 4 |
| 15 Nematode | 1 | .. | .. | .. | .. | .. | .. | .. | .. |
| 16 Amphipod | .. | .. | Rare. | 3 | 2 | 4 | Rare | .. | 180 |
| 17 Zœa | .. | .. | 1 | .. | .. | .. | .. | .. | Rare |
| 18 Gastropod post larvæ | .. | .. | Rare. | .. | .. | .. | .. | .. | .. |
| 19 Isopod | .. | .. | .. | .. | Rare. | 1 | .. | .. | .. |
| 20 Prawn Larvæ | .. | .. | .. | .. | .. | .. | Rare. | 1 | 1 |
| *Phyto Plankton—* | | | | | | | | | |
| 1 Navicula | 1,100 | .. | 7 | .. | .. | 1 | .. | 900 | 5,580 |
| 2 Coscinodiscus | .. | .. | .. | .. | .. | .. | .. | .. | 60 |
| 3 Gyrosigma | .. | .. | 60 | .. | .. | .. | .. | .. | .. |
| 4 Guinardia | .. | .. | .. | .. | .. | .. | .. | 60 | 2,22 |
| 5 Green algæ | .. | .. | .. | .. | 1 | 3 | .. | .. | .. |
| 6 Oscillatoria | .. | .. | .. | .. | .. | 254 | .. | .. | .. |
| 7 Rhizosolenium alata | .. | .. | .. | .. | .. | .. | .. | Rare. | .. |
| 8 Diploneis | .. | .. | .. | .. | .. | .. | .. | .. | Rare |

TABLE 4.

*Zoo-plankton 1961 S1 Numbers per c.c.*

| *Zoo-plankton.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Mesopodopsis .. | .. | .. | .. | 18 | 3 | 1 | 5 | Rare. | .. | .. | .. | .. |
| 2 Copepods .. | 4,140 | 720 | 3,880 | 6,300 | 5,470 | 5,070 | 1,020 | 480 | 1,520 | 720 | 1,680 | 1,080 |
| 3 Lepadid .. | .. | .. | .. | 3 | 1 | Rare. | 3 | 6 | 4 | 5 | 3 | .. |
| 4 Fish eggs. .. | .. | 25 | 28 | 24 | 1 | 13 | .. | Rare. | .. | .. | .. | .. |
| 5 Polychaete Post-larvae. | .. | 120 | 60 | 120 | .. | .. | .. | 96 | .. | .. | .. | .. |
| 6 Nauplii .. .. | 1,080 | 40 | 2,580 | 780 | 2,220 | 4,560 | 780 | 288 | 1,360 | 400 | 240 | 1,320 |
| 7 Medusae .. .. | 1 | 8 | .. | 5 | 38 | 3 | 187 | 68 | Rare. | Rare. | 12 | .. |
| 8 Fish larvae .. | 5 | Rare. | 13 | 6 | 1 | Rare. | .. | .. | .. | .. | .. | 8 |
| 9 Amphipod .. | .. | 20 | 60 | 120 | 60 | .. | 60 | 172 | .. | Rare. | 6 | .. |
| 10 Freshwater shrimp. | .. | .. | .. | 1 | .. | 10 | .. | Rare. | .. | .. | .. | .. |
| 11 Prawn larvae .. | 1 | .. | 1 | .. | 4 | 2 | .. | .. | .. | .. | .. | .. |
| 12 Obelia .. .. | .. | .. | .. | .. | Rare. | Rare. | .. | 48 | Rare. | 81 | .. | .. |
| 13 Megalopa .. .. | .. | 3 | .. | .. | 1 | .. | .. | .. | Rare. | Rare. | .. | .. |
| 14 Dipteran wing scale. | .. | .. | .. | .. | .. | .. | 60 | .. | .. | Rare. | .. | .. |
| 15 Water skater .. | .. | .. | .. | .. | .. | .. | .. | 2 | .. | .. | .. | .. |
| 16 Beetle larvae .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | 120 |
| 17 Polychætes .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 18 Crab gill with lepas. | .. | .. | .. | .. | .. | .. | .. | Rare. | .. | .. | .. | .. |
| 19 Amphipod moults | .. | .. | .. | .. | .. | .. | .. | .. | 2 | Rare. | 18 | 38 |
| 20 Caligus sp. .. | .. | .. | .. | .. | .. | .. | .. | .. | Rare. | Rare. | .. | .. |
| 21 Cypris .. .. | 60 | .. | 60 | .. | .. | .. | .. | .. | 160 | 240 | .. | 240 |
| 22 Bug larvae .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 60 | .. | .. |
| 23 Isopod .. .. | .. | .. | .. | .. | .. | .. | .. | .. | Rare. | .. | .. | .. |
| 24 Zoea .. .. | .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 25 Gastropod post .. larvæ. | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 26 Alpheids .. | .. | .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 5.

*Phyto plankton* 1961 *Sl Numbers per c.c.*

| (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Phyto Plantation— | | | | | | | | | | | | |
| 1 Navicula .. .. | 4,800 | 2,160 | 2,100 | 3,300 | 840 | .. | 60 | 384 | 2,45,600 | 13,200 | 2,640 | 360 |
| 2 Nitzchia closterium. | 300 | 12,960 | 3,000 | 2,520 | 120 | .. | 60 | .. | .. | 1,200 | .. | .. |
| 3 Gyrosigma .. | 120 | 120 | 860 | 1,140 | .. | 60 | .. | .. | 480 | 500 | .. | .. |
| 4 Oscillatoria .. | .. | 60 | 120 | 240 | .. | .. | .. | 48 | 80 | 400 | 480 | .. |
| 5 Chaetomorpha .. | .. | .. | .. | .. | .. | 2 | .. | 384 | .. | .. | .. | .. |
| 6 Microcystis .. | .. | .. | .. | .. | .. | .. | 600 | .. | .. | .. | .. | .. |
| 7 Bacillaria .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 8 Polysiphonia .. | .. | .. | .. | .. | .. | .. | .. | 2 | .. | .. | .. | .. |
| 9 Englena .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 160 | 1,680 | .. | .. |
| 10 Cladophora .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 160 | 240 | 360 |
| 11 Achnanthes .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 320 | .. | .. |
| 12 Enteromorpha .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 13 Pandorina .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 14 Melosira .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 80 | .. | .. |
| 15 Merismopedia .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 160 | .. | .. |
| 16 Diploneis .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. |
| 17 Guinardia .. | .. | 360 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 18 Nitschia seriatum | .. | 540 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 6.

*Zoo-Plankton* 1960 $S^2$ *Numbers per c.c.*

| (1) | *April.* (2) | *May.* (3) | *June.* (4) | *July.* (5) | *August.* (6) | *September.* (7) | *October.* (8) | *November.* (9) | *December* (10) |
|---|---|---|---|---|---|---|---|---|---|
| *Zoo Plankton—* | | | | | | | | | |
| 1 Isopods .. .. | .. | .. | .. | .. | | .. | 3 | .. | .. |
| 2 Polychaete post larvae | .. | .. | .. | .. | .. | 4 | .. | .. | .. |
| 3 Nauplii .. .. .. | .. | 104 | 196 | 499 | 1,826 | 120 | 2,040 | 120 | 600 |
| 4 Shrimps .. .. .. | .. | .. | .. | .. | Rare. | .. | .. | .. | .. |
| 5 Peridinium .. .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. |
| 6 Wing scale of Dipteran | - .. | .. | .. | .. | .. | .. | .. | .. | 60 |
| 7 Caligus sp. .. .. | .. | .. | .. | 1 | Rare. | .. | .. | .. | .. |
| 8 Copepods .. .. | .. | 224 | 4,700 | 1,592 | 2,085 | 278 | 360 | 60 | .. |
| 9 Vivipara .. .. | .. | .. | .. | Rare. | .. | .. | .. | .. | .. |
| 10 Prawn larvæ .. .. | Rare. | .. | .. | .. | .. | .. | .. | .. | Rare |
| 11 Mesopodopsis .. .. | 2,804 | 1,219 | Rare. | 75 | 9 | 2 | 194 | 78 | .. |
| 12 Fish Larvæ .. .. | .. | 6 | 60 | 1 | 1 | 1 | 5 | .. | .. |
| 13 Obelia .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | Rare. |
| 14 Lucifer .. .. .. | Rare. | .. | .. | .. | .. | .. | .. | .. | .. |
| 15 Lepadid .. .. .. | Rare. | .. | .. | 13 | 1 | .. | .. | Rare. | 2 |
| 16 Fish eggs .. .. | 1 | .. | .. | .. | .. | Rare. | .. | 10 | .. |
| 17 Medusæ .. .. .. | Rare. | .. | 4 | 3 | 3 | .. | 3 | .. | 84 |
| 18 Sagitta .. .. .. | .. | 4 | .. | .. | 18 | .. | .. | .. | .. |
| 19 Cypris .. .. .. | .. | .. | 7 | 51 | .. | .. | 180 | .. | .. |
| 20 Amphipods .. .. | .. | .. | 1 | 6 | 1 | 3 | .. | .. | .. |
| 21 Amphipod moults .. | .. | .. | .. | .. | .. | 10 | .. | .. | .. |

TABLE 7.

*Phyto-Plankton* 1960 $S_2$ *Numbers per c.c.*

| (1) | *April.* (2) | *May.* (3) | *June.* (4) | *July.* (5) | *August.* (6) | *September.* (7) | *October* (8) | *November.* (9) | *December.* (10) |
|---|---|---|---|---|---|---|---|---|---|
| *Phyto-Plankton—* | | | | | | | | | |
| 1 Spirulina .. .. .. | .. | 132 | .. | .. | .. | .. | .. | .. | .. |
| 2 Oscillatoria .. .. .. | .. | 4,020 | 106 | .. | .. | .. | .. | .. | .. |
| 3 Navicula .. .. .. | .. | 15,330 | 963 | .. | Rare. | 3,394 | 420 | 5,250 | 1,296 |
| 4 Gyrosigma .. .. .. | .. | 300 | .. | .. | .. | .. | 60 | 540 | 240 |
| 5 Suriella .. .. .. | .. | .. | .. | .. | .. | .. | .. | 180 | .. |
| 6 Guinardia .. .. .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 7 Thalassiosira .. .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 240 |
| 8 Chætoceras .. .. .. | .. | .. | 517 | .. | .. | .. | .. | .. | 180 |
| 9 Phæocystis .. .. .. | Rare. | .. | Rare. | .. | .. | .. | 60 | .. | Rare. |
| 10 Nostoc .. .. .. | .. | 88 | .. | .. | .. | .. | .. | .. | .. |
| 11 Phromidium .. .. .. | .. | 22 | .. | .. | .. | .. | .. | .. | .. |
| 12 Nitzchia closterium .. .. | .. | 3,180 | 60 | .. | .. | .. | .. | .. | .. |
| 3 Enteromorpha .. .. | .. | .. | .. | .. | .. | 14 | .. | .. | .. |

### TABLE 8.

*Zoo-Plankton* 1961 $S_2$. *Numbers per c.c.*

| (1)<br>*Zoo-Plankton.*— | *January.*<br>(2) | *February.*<br>(3) | *March.*<br>(4) | *April.*<br>(5) | *May.*<br>(6) | *June.*<br>(7) | *July.*<br>(8) | *August.*<br>(9) | *September.*<br>(10) | *October.*<br>(11) | *November.*<br>(12) | *December.*<br>(13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Fresh water shrimp. | .. | .. | .. | 1 | 3 | .. | .. | 1 | .. | .. | .. | .. |
| 2 Medusae .. | 302 | 349 | 600 | 123 | 507 | 577 | 71 | 227 | 197 | 308 | 117 | 233 |
| 3 Fish eggs .. | Rare. | 3 | 15 | 6 | .. | 15 | .. | 4 | 1 | .. | 1 | .. |
| 4 Copepods .. | 5,475 | 220 | 1,080 | 1,020 | 1,860 | 3,540 | 660 | 288 | 480 | 909 | 137 | 1,604 |
| 5 Nauplii .. .. | 840 | 961 | 1,320 | 60 | 1,320 | 2,580 | 420 | 672 | 720 | 807 | 1,107 | 895 |
| 6 Mesopodopsis .. | .. | .. | .. | 4 | .. | .. | .. | 6 | .. | 1 | 20 | 2 |
| 7 Dipteran wingscale. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. |
| 8 Gastropod post-larvae. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. |
| 9 Polychaete Post-larvae. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | 1 |
| 10 Nematode .. | .. | .. | .. | .. | 60 | .. | .. | .. | 80 | .. | .. | .. |
| 11 Penaeus indicus larvae | .. | 220 | .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. |
| 12 Fish larvae .. | Rare. | .. | 50 | .. | .. | 1 | .. | 20 | .. | .. | 2 | 5 |
| 13 Water beetle larvae. | .. | 1 | 60 | .. | .. | .. | 60 | 48 | .. | .. | .. | .. |
| 14 Bug larvae .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 | 22 | .. | .. |
| 15 Spionid .. .. | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 16 Caligus sp. .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 | 1 | .. |
| 17 Euglena .. .. | 470 | .. | .. | .. | .. | .. | .. | .. | 80 | 2,116 | 173 | .. |
| 18 Amphipod moults. | 1 | .. | .. | .. | .. | .. | .. | .. | 33 | 10 | 9 | 59 |
| 19 Lepadid .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| 20 Amphipods .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 11 | 1 | 17 |
| 21 Megalopa .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| 22 Obelia .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| 23 Cypris .. .. | 3 | .. | .. | .. | .. | .. | .. | .. | .. | 153 | 173 | 404 |
| 24 Foraminiferan .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 22 | 13 | .. |
| 25 Gastropod egg raft. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 |
| 26 Water mite .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 11 |
| 27 Nothalca .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 11 |

TABLE 9.

*Phyto-Plankton* $S_2$ 1961 *Number per c.c.*

| (1) *Phyto-Plankton*— | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Nitzchia closterium. | 780 | 1,380 | .. | 1,800 | 60 | .. | .. | .. | .. | 196 | .. | .. |
| 2 Navicula .. .. | 4,695 | 1,680 | 120 | 1,440 | 5,460 | .. | .. | 96 | 9,760 | 5,738 | 1,880 | 65 |
| 3 Gyrosigma .. | 300 | .. | .. | 300 | .. | .. | 240 | .. | 640 | 153 | 53 | .. |
| 4 Thalassiosira .. | .. | .. | .. | 2,100 | .. | .. | .. | .. | .. | .. | .. | .. |
| 5 Phormidium .. | .. | .. | .. | 60 | .. | .. | .. | .. | 20,000 | .. | .. | .. |
| 6 Chaetomorpha .. | .. | .. | .. | .. | 60 | .. | .. | 48 | .. | .. | .. | .. |
| 7 Oscillatoria .. | .. | 2 | .. | .. | 60 | .. | .. | .. | .. | 109 | 40 | 360 |
| 8 Phaeocystis .. | .. | .. | .. | .. | .. | .. | .. | 3 | .. | .. | .. | .. |
| 9 Cladophora .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 44 | .. | .. |
| 10 Achnanthes .. | .. | .. | .. | .. | .. | .. | .. | .. | 480 | 65 | .. | .. |
| 11 Diploneis .. | .. | .. | .. | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 12 Bacillaria .. .. | .. | .. | 60 | .. | .. | .. | .. | .. | 80 | .. | .. | .. |
| 13 Merismopedia .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 22 | .. | .. |
| 14 Anabaena .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 22 | .. | .. |
| 15 Coscinodiscus .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 13 | .. |
| 16 Spirogyra .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 27 | 22 |
| 17 Enteromorpha .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| 18 Nitzschia seriatum. | .. | 240 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 19 Pleodorina .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 20 Bacillariaceae .. | .. | 300 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 10.

*Meteorology of Fish Farm* 1960.

| *Months.* | *Air temperature.* | | *Wet bulb.* | *Dry bulb.* | *Relative humidity.* | *Water surface temperature.* | *Specific gravity.* |
|---|---|---|---|---|---|---|---|
| | *Maximum.* | *Minimum.* | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | °c | °c | | | PER CENT. | °c | |
| January .. .. .. | 26·5 | 23·5 | .. | .. | .. | 26·5 | 1·001 |
| February .. .. .. | 27·5 | 24·5 | .. | .. | .. | .. | .. |
| March .. .. .. | 30·5 | 26·5 | .. | .. | .. | 29·5 | 1·010 |
| April .. .. .. | 31·0 | 28·25 | .. | .. | .. | 31·0 | 1·010 |
| May .. .. .. | 34·75 | 30·5 | .. | .. | .. | 30·5 | 1·010 |
| June .. .. .. | 34·5 | 31·0 | .. | .. | .. | 29·25 | 1·010 |
| July .. .. .. | 31·25 | 29·0 | .. | .. | .. | 30·25 | 1·010 |
| August .. .. .. | 33·25 | 29·25 | .. | .. | .. | 30·0 | 1·010 |
| September .. .. | 30·0 | 27·25 | 80·25 | 80·2 | 74·5 | 30·0 | 1·015 |
| October .. .. .. | 29·75 | 27·25 | 85 | 78 | 66·5 | 29·75 | 1·021 |
| November .. .. | 26·25 | 23·75 | 75 | 76 | 82·0 | 26·5 | 1·006 |
| December .. .. | 26·75 | 23·75 | 80 | 76 | 83·0 | 27·5 | 1·001 |

TABLE 11.

*Meteorology* 1961.

| *Months.* | *Air temperature.* | | *Wet bulb.* | *Dry bulb.* | *Relative humidity.* | *Weather.* | *Water surface temperature.* | *Specific gravity.* |
|---|---|---|---|---|---|---|---|---|
| | *Maximum.* | *Minimum.* | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | °c | °c | | | PER CENT. | | °c | |
| January .. .. .. | 26·5 | 24·5 | 75 | 80 | 79 | Showers. | 28·0 | 1·007 |
| February .. .. .. | 27·5 | 25·5 | 78 | 82 | 83 | Fair .. | 29·0 | 1·010 |
| March .. .. .. | 29·0 | 27·25 | 82 | 87 | 80 | Dry .. | 30·0 | 1·016 |
| April .. .. .. | 32·5 | 30·5 | 80 | 86 | 76 | Dry .. | 32·0 | 1·020 |
| May .. .. .. .. | 33·5 | 31·5 | 81 | 80 | 66 | Dry .. | 31·0 | 1·016 |
| June .. .. .. | 32·0 | 29·0 | 77 | 84 | 72 | Fair .. | 30·0 | 1·016 |
| July .. .. .. .. | 31·0 | 27·5 | 82 | 86 | 84 | Wet .. | 29·5 | 1·010 |
| August .. .. .. | 31·0 | 26·5 | 79 | 82 | 87 | Wet .. | 30·5 | 1·005 |
| September .. .. .. | 30·0 | 27·5 | 82 | 86 | 84 | Wet .. | 31·5 | 1·001 |
| October .. .. .. | 29·0 | 26·5 | 83 | 86 | 84 | Cloudy .. | 32·0 | 1·010 |
| November .. .. .. | 27·5 | 25·5 | 78 | 82 | 84 | Fair .. | 29·0 | 1·010 |
| December .. .. .. | 27·5 | 25·5 | 76 | 80 | 83 | Fair .. | 28·0 | 1·010 |

TABLE 12.

*Hydrology of Estuarine Fish Farm.*

1960 Pond S1.

| *Months.* | *Surface Temperature.* | *Specific gravity.* | *Turbidity.* | *Ph. value.* | *Salinity.* | *Oxygen.* | *Silicate.* |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | °c. | | CMS. | | %o | c.c./L | *Mgm/L* |
| January .. .. .. | 24·5 | 1·001 | 52·0 | 8·7 | 27·1 | 4·75 | 24·0 |
| February .. .. .. | 25·0 | 1·010 | 54·5 | 8·7 | 29·6 | 4·40 | 39·6 |
| March .. .. .. | 26·5 | 1·012 | 29·75 | 8·7 | 31·0 | 4·50 | 53·2 |
| April .. .. .. | 27·0 | 1·012 | 45·0 | 8·4 | 35·6 | 5·75 | 52·1 |
| May .. .. .. | 27·5 | 1·020 | 41·0 | 8·4 | 35·6 | 4·34 | 50·0 |
| June .. .. .. | 26·5 | 1·020 | 41·5 | 8·4 | 36·1 | 4·27 | 63·3 |
| July .. .. .. | 27·5 | 1·020 | 48·0 | 8·4 | 36·2 | 4·34 | 62·5 |
| August .. .. .. | 28·0 | 1·020 | 54·5 | 7·4 | 36·0 | 4·50 | 69·5 |
| September .. .. | 28·5 | 1·021 | 71·0 | 8·0 | 31·06 | 4·06 | 62·0 |
| October .. .. .. | 27·5 | 1·021 | 56·5 | 7·8 | 21·25 | 4·69 | 31·25 |
| November .. .. | 25·5 | 1·010 | 76·0 | 7·6 | 10·15 | 4·41 | 11·25 |
| December .. .. | 26·0 | 1·001 | 107·0 | 7·8 | 20·6 | 4·06 | 11·30 |

TABLE 13.

*Hydrology of Estuarine Fish Farm.*

1961 Pond S. I.

| *Months.* | *Surface Temp.* | *Sp. Gr.* | *Turbidity.* | *Salinity.* | *Oxygen.* | *Carbon-dioxide.* | *Carbonate.* | *Bicar-bonate.* | *Silicate.* | *Phosphate.* | *Ph.* | *Depth* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| | | | CMS. | of%. | *cc/L.* | PPM. | PPM. | PPM. | MGM/L. | PPM | | |
| January | 26·5°c | 1·010 | 130·0 | 22·78 | 4·2 | 1·1 | .. | .. | 10·0 | .. | 7·6 | 5′0″ |
| February | 27·0°c | 1·012 | 109·0 | 25·82 | 4·06 | 1·0 | .. | .. | 22·0 | .. | 7·6 | 4′6″ |
| March | 27·5°c | 1·012 | 120·0 | 30·51 | 5·63 | Nil. | .. | .. | 32·12 | .. | 8·0 | 4′3″ |
| April | 28·5°c | 1·020 | 75·5 | 35·15 | 3·25 | Nil. | 3·5 | 32·0 | 48·0 | 1·39 | 8·4 | .. |
| May | 30·5°c | 1·020 | 84·0 | 31·6 | 3·16 | Nil. | 1·8 | 39·65 | 36·0 | 0·88 | 8·0 | .. |
| June | 29·5°c | 1·020 | 72·5 | 27·75 | 4·06 | Nil. | 1·5 | 20·13 | 24·25 | 0·72 | 8·1 | .. |
| July | 28·0°c | 1·012 | 85·0 | 16·75 | 4·2 | Nil. | 1·6 | 32·5 | 17·50 | .. | 8·2 | .. |
| August | 28·5°c | 1·010 | 91·5 | 20·3 | 4·36 | 2·5 | 1·5 | 28·0 | 7·50 | .. | 8·6 | .. |
| September | 31·5°c | 1·010 | 75·5 | 19·9 | 3·98 | 1·8 | 2·0 | 29·0 | 7·80 | 0·72 | 8·4 | .. |
| October | 31·5°c | 1·010 | 80·5 | 17·75 | 4·55 | 2 | 1·5 | 36·5 | 6·75 | .. | 7·8 | .. |
| November | 28·0°c | 1·010 | 80·0 | 16·66 | 4·6 | 1·5 | 1·5 | 43·01 | 8·50 | 0·68 | 7·8 | .. |
| December | 27·5°c | 1·010 | 86·5 | 17·25 | 4·13 | 1·2 | 2·5 | 41·5 | 8·0 | .. | 8·2 | .. |

### Table 14.

### *Hydrology of Estuarine Fish Farm.*

### 1960 Pond S. II.

| *Months.*<br>(1) | *Surface Temperature.*<br>(2)<br>°c. | *Specific gravity.*<br>(3) | *Turbidity.*<br>(4)<br>cms. | *Ph. value.*<br>(5) | *Salinity.*<br>(6)<br>%. | *Oxygen.*<br>(7)<br>*c.c./L.* | *Silicate.*<br>(8)<br>*Mgm.* |
|---|---|---|---|---|---|---|---|
| January .. .. .. | 25·5 | 1·001 | 44·5 | 8·7 | 24·58 | 4·75 | 48·3 |
| February .. .. | 26·0 | 1·010 | 48·2 | 8·7 | 28·6 | 4·00 | 53·3 |
| March .. .. .. | 26·5 | 1·010 | 50·5 | 8·7 | 31·1 | 4·62 | 55·5 |
| April .. .. .. | 26·5 | 1·020 | 52·0 | 8·4 | 34·1 | 3·1 | 52·1 |
| May .. .. .. | 27·0 | 1·020 | 44·0 | 8·0 | 35·6 | 5·57 | 56·8 |
| June .. .. .. | 27·5 | 1·020 | 44·0 | 8·0 | 35·5 | 3·57 | 83·3 |
| July .. .. .. | 27·5 | 1·020 | 49·0 | 8·2 | 36·8 | 4·19 | 65·7 |
| August .. .. .. | 28·0 | 1·020 | 52·0 | 8·1 | 36·6 | 4·06 | 83·3 |
| September .. .. | 28·5 | 1·021 | 79·0 | 7·2 | 32·13 | 3·08 | 71·4 |
| October .. .. .. | 26·0 | 1·021 | 116·0 | 7·6 | 24·85 | 3·85 | 27·7 |
| November .. .. | 25·5 | 1·001 | 120·0 | 7·6 | 16·2 | 4·62 | 12·0 |
| December .. .. | 25·5 | 1·001 | 110·0 | 7·6 | 22·0 | 4·13 | 10·12 |

TABLE 15.

*Hydrology of Estuarine fish farm.*

1961 *Pond S. II.*

| *Months.* (1) | *Surface Temp.* (2) | *Sp. Gr.* (3) | *Turbidity.* (4) CM. | *Salinity.* (5) % | *Oxygen.* (6) cc/L. | *Ph.* (7) MGM. | *Silicate.* (8) PPM. | *Carbonate.* (9) PPM. | *Bicarbonate.* (10) PPM. | *Carbon-dioxide.* (11) PPM. | *Phosphate.* (12) PPM. | *Depth.* (13) F. ins. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January .. .. .. .. | 26·5° | 1·010 | 125·0 | 23·14 | 4·41 | 7·6 | 10·0 | .. | .. | 1·1 | .. | 4′ 3″ |
| February .. .. .. .. | 27·0° | 1·011 | 110·0 | 25·02 | 3·85 | 7·6 | 30·0 | .. | .. | 1·0 | .. | 4′8½″ |
| March .. .. .. .. | 28·0° | 1·012 | 122·0 | 30·14 | 5·95 | 7·8 | 46·0 | .. | .. | 2·0 | .. | 3′10″ |
| April .. .. .. .. | 29·0° | 1·020 | 114·0 | 37·93 | 3·38 | 8·2 | 51·35 | 5·5 | 37·5 | 1·0 | 1·32 | .. |
| May .. .. .. .. | 30·5° | 1·020 | 117·0 | 30·9 | 3·00 | 8·2 | 35·3 | 1·0 | 46·6 | Nil. | 1·39 | .. |
| June .. .. .. .. | 29·5° | 1·020 | 94·5 | 30·25 | 3·97 | 7·8 | 29·60 | 1·1 | 48·8 | Nil. | 1·32 | .. |
| July .. .. .. .. | 28·0° | 1·018 | 98·0 | 26·5 | 3·75 | 7·6 | 25·25 | 1·5 | 25·25 | 0·5 | .. | .. |
| August .. .. .. .. | 28·5° | 1·012 | 97·0 | 25·05 | 3·1 | 8·2 | 26·5 | 1·8 | 26·5 | 2·2 | 0·92 | .. |
| September .. .. .. .. | 31·5° | 1·010 | 92·0 | 23·7 | 3·6 | 8·4 | 29·40 | 1·8 | 29·4 | 2·0 | .. | .. |
| October .. .. .. .. | 32·0° | 1·010 | 96·0 | 21·6 | 3·1 | 7·8 | 46·33 | 1·6 | 40·33 | 2·5 | 0·92 | .. |
| November .. .. .. .. | 31·5° | 1·010 | 85·5 | 19·33 | 3·99 | 7·6 | 41·175 | 1·5 | 41·78 | 2·5 | 0.71 | .. |
| December .. .. .. .. | 28·0° | 1·010 | 94·5 | 19·89 | 4·2 | 8·2 | 43·31 | 1·5 | 48·8 | 2·0 | 0·87 | .. |

### TABLE 16-A.

*Growth studies of chanos chanos in "S. 1."*

Numbers stocked—200. Date of stocking—17th February 1961.

| *Date.* | *Size range in mm.* | | *Weight range in grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 17th February 1961 | 82 | 135 | 8 | 10 |
| 25th March 1961 | 150 | 216 | 40 | 90 |
| 22nd April 1961 | 195 | 267 | 55 | 145 |
| 29th May 1961 | 195 | 337 | 83 | 270 |
| 27th June 1961 | 255 | 380 | 230 | 380 |
| 15th July 1961 | 330 | 470 | 240 | 350 |
| 19th August 1961 | 342 | 380 | 310 | 400 |
| 16th September 1961 | 356 | 372 | 350 | 410 |

### TABLE 16-B.

*Growth studies of chanos chanos in "S. 2."*

Numbers stocked—100. Date of stocking—17th February 1961.

| *Date.* | *Size range in mm.* | | *Weight range in grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 17th February 1961 | 62 | 125 | 75 | 14 |
| 25th March 1961 | 157 | 190 | 30 | 65 |
| 22nd April 1961 | 155 | 269 | 50 | 140 |
| 29th May 1961 | 195 | 298 | 62 | 180 |
| 27th June 1961 | 216 | 354 | 70 | 320 |
| 15th July 1961 | 225 | 377 | 80 | 572 |
| 19th August 1961 | 287 | 359 | 205 | 320 |
| 16th September 1961 | 313 | 384 | 250 | 400 |

### TABLE 17-A.

*Growth studies of chanos chanos in " S. 5."*

Number stocked—4350.

Date of stocking—1st June 1960.

| *Date.* | *Size range in mm.* | | *Weight range in grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 1st June 1960 | 50 | 85 | 0·5 | 2 |
| 27th August 1960 | 90 | 135 | 19 | 34 |
| 27th September 1960 | 140 | 180 | 32 | 56 |
| 10th October 1960 | 120 | 195 | 40 | 95 |
| 30th November 1960 | 155 | 220 | 70 | 120 |
| 31st December 1960 | 115 | 235 | 52 | 155 |
| 23rd February 1961 | 172 | 296 | 60 | 130 |
| 11th March 1961 | 112 | 297 | 90 | 150 |
| | (Partly disposed by sale to thin out population.) | | | |
| 27th April 1961 | 215 | 276 | 90 | 150 |
| 2nd June 1961 | 243 | 264 | 110 | 150 |
| 29th July 1961 | 259 | 300 | 160 | 250 |
| 24th August 1961 | 203 | 300 | 110 | 240 |

### TABLE 17-B.

*Growth studies of chanos chanos in " S. 3."*

Number stocked—100 from " S. 5."

Date of transference—23rd February 1961.

| *Date.* | *Size range in mm.* | | *Weight range in grams.* | |
|---|---|---|---|---|
| | *Minimum.* | *Maximum.* | *Minimum.* | *Maximum.* |
| (1) | (2) | (3) | (4) | (5) |
| 23rd February 1961 | 172 | 251 | 52 | 155 |
| 18th March 1961 | 220 | 264 | 85 | 170 |
| 26th April 1961 | 212 | 260 | 80 | 120 |
| 29th May 1961 | 207 | 267 | 100 | 140 |
| | (Not available in June and July.) | | | |
| 24th August 1961 | 272 | 276 | 170 | 180 |

## TABLE 18.

*Plankton S. 5.—1960 Numbers per c c.*

| (1) | *April.* (2) | *May.* (3) | *June.* (4) | *July.* (5) | *August.* (6) | *September.* (7) | *October.* (8) | *November.* (9) | *December.* (10) |
|---|---|---|---|---|---|---|---|---|---|
| *Zoo plankton*— | | | | | | | | | |
| 1 Naupli | 5,740 | 3,717 | 590 | 2,777 | 83 | 789 | 912 | .. | 540 |
| 2 Shrimp | .. | .. | .. | .. | .. | .. | .. | .. | Rare. |
| 3 Peridinium | .. | 3,781 | .. | .. | .. | .. | .. | .. | .. |
| 4 Water mite | .. | .. | .. | .. | Rare. | .. | .. | .. | .. |
| 5 Rotifer | .. | .. | .. | .. | .. | 60 | 96 | .. | .. |
| 6 Lepadid | .. | 1 | 13 | 14 | 12 | 14 | 3 | .. | 1 |
| 7 Copepods | 1,716 | 3,516 | 1,804 | 4,118 | 143 | 2,107 | 2,192 | .. | 1,140 |
| 8 Vivipara | .. | .. | .. | 24 | .. | .. | .. | .. | .. |
| 9 Sagitta | .. | .. | .. | 21 | .. | .. | .. | 1 | .. |
| 10 Wing scale of Dipteran | .. | .. | .. | .. | .. | .. | .. | .. | 360 |
| 11 Fish larvae | .. | Rare. | 33 | Rare. | 2 | .. | .. | 16 | 1 |
| 12 Mesoposdopsis | .. | .. | .. | 1 | 19 | 1 | 26 | 16 | 2 |
| 13 Lucifer | .. | .. | .. | Rare. | .. | .. | Rare. | .. | .. |
| 14 Cypris | .. | Rare. | .. | 13 | .. | .. | .. | .. | .. |
| 15 Amphipod | .. | 1 | 131 | 27 | 36 | .. | .. | .. | .. |
| 16 Amphipod moults | .. | .. | .. | .. | .. | 1 | 1 | .. | .. |
| 17 Prawn larvae | .. | .. | .. | .. | .. | .. | 1 | Rare. | 1 |
| 18 Medusae | .. | .. | .. | .. | .. | .. | 1 | .. | 3 |
| 19 Polychaete Post larvae | .. | .. | 121 | .. | .. | .. | .. | .. | .. |
| 20 Nemotode | .. | Rare. | .. | Rare. | .. | .. | .. | .. | Rare. |
| 21 Fish eggs | .. | .. | 37 | .. | .. | .. | Rare. | .. | .. |
| 22 Argulids | .. | .. | 3 | .. | .. | .. | .. | .. | .. |
| 23 Ceratium furca | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 24 Zoea | .. | .. | .. | .. | .. | .. | . | .. | .. |
| 25 Gastropod post larvae | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 26 Nepa | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 27 Obelia | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| *Phyto Plankton*— | | | | | | | | | |
| 1 Phaeocystis | 20,724 | 96 | 19 | 27 | .. | .. | .. | .. | .. |
| 2 Chaetoceras | 220 | 156,800 | .. | .. | .. | .. | .. | 780 | .. |
| 3 Rhizosolenium alata | 220 | .. | .. | .. | .. | .. | .. | .. | .. |
| 4 Navicula | 264 | 8,928 | 3,202 | 70 | 618 | .. | 1,056 | 1,560 | 600 |
| 5 Nitzschia closterium | 440 | .. | .. | .. | .. | .. | .. | 780 | .. |
| 6 Microcystis | .. | .. | 4,231 | .. | .. | .. | .. | .. | .. |
| 7 Gyrosigma | .. | .. | 460 | .. | .. | .. | .. | 180 | 480 |
| 8 Thalassiosira | .. | .. | .. | .. | .. | .. | 48 | . | .. |
| 9 Oscillatoria | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 10 Guinardia | .. | .. | .. | .. | .. | .. | .. | 60 | .. |
| 11 Suriella | .. | .. | .. | .. | .. | .. | .. | 60 | .. |
| 12 Pleodorina | .. | .. | .. | .. | .. | .. | .. | 60 | .. |
| 13 Nostoc | .. | .. | .. | .. | .. | .. | .. | .. | Rare. |
| 14 Merismopedia | .. | .. | .. | .. | .. | .. | .. | .. | 60 |

## TABLE 19.

*S. 5.—1961 Number per c c.*

| *Zoo plankton.*<br>(1) | *January.*<br>(2) | *February.*<br>(3) | *March.*<br>(4) | *April.*<br>(5) | *May.*<br>(6) | *June.*<br>(7) | *July.*<br>(8) | *August.*<br>(9) | *September.*<br>(10) | *October.*<br>(11) | *November.*<br>(12) | *December.*<br>(13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961— | | | | | | | | | | | | |
| 1 Lepadid | 4 | 15 | .. | 1 | 1 | .. | .. | .. | 4 | 3 | .. | .. |
| 2 Copepods | 1,920 | 2,340 | 9,840 | 1,680 | 2,280 | 1,140 | 300 | 1,152 | 1,120 | 1,560 | 2,040 | 480 |
| 3 Nauplii | 2,500 | 2,880 | 1,670 | 1,680 | 1,320 | 1,800 | 780 | 1,488 | 160 | 360 | 720 | 600 |
| 4 Mesopodopsis | .. | 5 | 10 | 6 | 30 | 273 | 10 | 30 | 2 | 6 | .. | 3 |
| 5 Medusae | .. | 60 | 2 | 6 | 8 | 7 | 2 | 17 | 1 | 38 | 28 | 75 |
| 6 Polychaetepost larvae | .. | 180 | .. | 60 | .. | .. | .. | 43 | .. | .. | .. | .. |
| 7 Prawn larvae | .. | .. | 1 | .. | 2 | 2 | .. | .. | .. | .. | .. | .. |
| 8 Cypris | .. | .. | .. | .. | 61 | .. | .. | 43 | 160 | 360 | 240 | 600 |
| 9 Fish larvae | 3 | Rare. | .. | .. | 1 | .. | .. | .. | 3 | .. | 1 | .. |
| 10 Obelia | .. | 2 | 2 | .. | 180 | 150 | .. | .. | .. | .. | .. | .. |
| 11 Brachionus | .. | .. | .. | .. | 0 | .. | .. | .. | .. | .. | .. | .. |
| 12 Spionid | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. |
| 13 Dipteran wing scale | .. | .. | .. | .. | .. | 25 | .. | .. | .. | .. | .. | .. |
| 14 Fish eggs | Rare. | 15 | 2 | .. | .. | 50 | .. | 3 | 2 | .. | .. | .. |
| 15 Amphipod | Rare. | .. | .. | .. | .. | 120 | .. | 6 | 163 | .. | 11 | 4 |
| 16 Peridinium | 120 | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. |
| 17 Amphipod moults | 1 | .. | .. | .. | .. | .. | .. | 1 | 16 | .. | .. | .. |
| 18 Lamellibranch post larvae | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 19 Pandorina | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. |
| 20 Megalopa | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. |
| 21 Caligus sp. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1 | 1 | .. |
| 22 Vorticella | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 23 Water beetle | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 24 Foraminiferan | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 25 Gastropod post larvae | 60 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 26 Ceratium furca | 60 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 27 Zoea | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 28 Nepa | Rare. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

### TABLE 20.

*Phyto plankton S. 5.—1961 Numbers per c c.*

| (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phyto plankton—* | | | | | | | | | | | | |
| 1 Oscillatoria | .. | .. | .. | 34,500 | 360 | .. | .. | .. | 160 | 1,200 | 2,760 | 1,200 |
| 2 Navicula | 600 | .. | 6,900 | .. | 11,640 | .. | .. | .. | .. | 3,600 | 15,400 | 5,400 |
| 3 Gyrosigma | 480 | 120 | .. | .. | 240 | .. | .. | .. | .. | .. | .. | 240 |
| 4 Phaeocystis | .. | .. | .. | .. | 1 | 75 | | .. | .. | .. | .. | .. |
| 5 Nitzschia closterium | .. | .. | 2,580 | .. | 480 | .. | .. | .. | .. | .. | .. | 120 |
| 6 Microcystis | .. | .. | .. | .. | 1,140 | .. | .. | .. | .. | .. | .. | .. |
| 7 Phormidium | .. | .. | .. | .. | .. | 60 | 540 | 48 | .. | .. | .. | .. |
| 8 Guinardia | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. |
| 9 Melosira | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. |
| 10 Polysiphonia | .. | .. | .. | .. | .. | 50 | .. | .. | .. | | .. | .. |
| 11 Enteromorpha | .. | .. | .. | .. | .. | .. | 1 | .. | 1 | .. | .. | .. |
| 12 Merismopedia | .. | 60 | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 13 Achnanthes | .. | .. | .. | .. | .. | .. | .. | .. | 80 | 120 | 1,800 | .. |
| 14 Thalassiosira | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. | .. |
| 15 Fragillaria | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 | .. |
| 16 Chaetomorpha | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 17 Nostoc | **Rare.** | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

TABLE 21.

*Plankton S. 3.—1961 Number per cc.*

| | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| ***Zoo plankton—*** | | | | | | | | | | | | |
| 1 Mesopodopsis | Rare. | 9 | .. | 83 | 4 | 20 | 54 | 7 | 58 | .. | .. | .. |
| 2 Medusae | 151 | 13 | 11 | 243 | 243 | 265 | 10 | 83 | 12 | 23 | 36 | 50 |
| 3 Fish eggs | .. | .. | 26 | 167 | 49 | 94 | 397 | 162 | 99 | .. | .. | .. |
| 4 Cypris | .. | .. | .. | 180 | 60 | 60 | 180 | 48 | 80 | .. | 240 | 240 |
| 5 Copepods | 9,560 | 1,980 | 3,660 | 3,000 | 2,640 | 1,500 | 840 | 528 | 1,520 | 1,760 | 960 | 360 |
| 6 Naupiil | 480 | 1,020 | 5,660 | 1,680 | 3,480 | 2,820 | 360 | 576 | 640 | 560 | 480 | 380 |
| 7 Fish fry | .. | .. | .. | .. | 5 | .. | .. | 2 | 5 | 2 | .. | 10 |
| 8 Nematodes | 6 | .. | .. | .. | 120 | .. | .. | .. | .. | .. | .. | .. |
| 9 Obelia | .. | .. | .. | .. | 3 | .. | .. | .. | .. | .. | .. | .. |
| 10 Penaeus indicus | .. | .. | .. | .. | .. | 5 | .. | .. | .. | Rare. | .. | .. |
| 11 Amphipod | .. | .. | .. | .. | .. | .. | 120 | 96 | 80 | .. | .. | .. |
| 12 Caligus sp. | .. | .. | .. | .. | .. | .. | 38 | .. | 12 | .. | .. | .. |
| 13 Water mite | .. | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | .. |
| 14 Anuraea | .. | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 15 Gastropods | .. | .. | .. | .. | .. | .. | .. | 4 | .. | .. | .. | .. |
| 16 Water beetle | 6 | .. | .. | .. | .. | .. | .. | 48 | .. | .. | .. | .. |
| 17 Zoea | .. | .. | .. | .. | .. | .. | .. | 144 | .. | .. | .. | .. |
| 18 Amphipod moults | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 25 |
| 19 Fish larvae | Rare. | 2 | 25 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| *Phyto plankton—* | | | | | | | | | | | | |
| 1 Pleodorina | .. | 120 | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. |
| 2 Navicula | 13 | 60 | .. | 40,140 | 120 | .. | .. | .. | .. | .. | .. | 240 |
| 3 Chaetophora | .. | .. | .. | 240 | .. | .. | .. | .. | .. | .. | .. | .. |
| 4 Nitzschia closterium. | .. | .. | .. | 900 | .. | .. | .. | .. | .. | .. | .. | .. |
| 5 Chaetoceras | .. | .. | .. | 60 | .. | .. | .. | .. | .. | .. | .. | .. |
| 6 Nostoc | .. | .. | .. | 180 | .. | .. | .. | .. | .. | .. | .. | .. |
| 7 Phaeocystis | .. | .. | .. | 375 | .. | 1 | .. | .. | .. | .. | .. | .. |
| 8 Oscillatoria | .. | 60 | .. | .. | 120 | .. | .. | .. | .. | .. | .. | .. |
| 9 Merismopedia | .. | 120 | .. | .. | 60 | .. | .. | .. | .. | .. | .. | 120 |
| 10 Polysiphonia | .. | .. | .. | .. | .. | .. | 63 | .. | .. | .. | .. | .. |
| 11 Gyrosigma | 19 | .. | .. | .. | .. | .. | 60 | .. | .. | .. | .. | 240 |
| 12 Cosmarium | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 120 |

TABLE 22.

*Hydrology of Estuarine Fish Farm Ponds*—SV. 1960.

| *Months.* (1) 1960. | *Temperature.* (2) °c. | *Specific gravity.* (3) | *Turbidity.* (4) CM. | *PH. Value.* (5) | *Salinity.* (6) PER CENT. | *Oxygen.* (7) cc/L. | *Silicate.* (8) MGM. |
|---|---|---|---|---|---|---|---|
| January .. .. .. | .. | .. | .. | .. | .. | .. | .. |
| February .. .. .. | 27·5 | 1·001 | 48·0 | 8·7 | 31·59 | 3·54 | 65·8 |
| March .. .. .. | 26·0 | 1·001 | 44·4 | 8·7 | 36·1 | 4·52 | 58·2 |
| April .. .. .. | 27·5 | 1·02 | 43·0 | 8·4 | 39·4 | 4·26 | 65·8 |
| May .. .. .. | 27·0 | 1·02 | 42·0 | 8·4 | 42·72 | 4·27 | 69·4 |
| June .. .. .. | 25·0 | 1·02 | 29·5 | 8·4 | 43·4 | 4·48 | 62·5 |
| July .. .. .. | 27·5 | 1·021 | 44·0 | 8·2 | 44·0 | 4·06 | 53·2 |
| August .. .. .. | 28·0 | 1·021 | 48·0 | 8·1 | 43·5 | 5·11 | 50·0 |
| September .. .. | 27·5 | 1·021 | 69·0 | 8·2 | 34·38 | 4·41 | 45·6 |
| October .. .. .. | 27·0 | 1·01 | 71·0 | 8·0 | 21·5 | 4·41 | 24·0 |
| November .. .. | 26·0 | 1·001 | 64·25 | 8·4 | 9·95 | 4·41 | 10·75 |
| December .. .. .. | 25·56 | 1·001 | 92·0 | 8·5 | 15·0 | 4·55 | 10·5 |

## TABLE 23.

*Hydrology of Estuarine Fish Farm—Pond SV.* 1961.

| *Months.* (1) 1961. | *Temperature.* (2) °C. | *Specific gravity.* (3) | *Turbidity.* (4) CM. | *Salinity.* (5) 0/00. | *Oxygen.* (6) *cc/L.* | *PH. Value.* (7) | *Silicate.* (8) MGM/L | *Carbon-dioxide.* (9) PPM. | *Carbonate.* (10) PPM. | *Bi-carbonate.* (11) PPM. | *Phosphate.* (12) PPM. | *Depth.* (13) FT. INS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January .. .. | 26·5 | 1·1012 | 72·0 | 23·49 | 4·41 | 8·0 | 10·0 | 1·1 | .. | .. | .. | 4·3 |
| February .. .. | 27·0 | 1·012 | 75·0 | 25·48 | 3·92 | 8·0 | 27·5 | 1·0 | .. | .. | .. | 4·0 |
| March .. .. .. | 28·0 | 1·012 | 57·5 | 32·78 | 5·18 | 8·2 | 41·6 | .. | .. | .. | .. | 3·9 |
| April .. .. .. | 28·5 | 1·02 | 36·5 | 36·9 | 3·25 | 8·4 | 43·5 | Nil. | 2·0 | 26·0 | 1·87 | .. |
| May .. .. .. | 31·0 | 1·02 | 53·5 | 31·96 | 2·6 | 7·6 | 30·25 | Nil. | 1·0 | 25·5 | 1·89 | .. |
| June .. .. .. | 28·5 | 1·016 | 58·5 | 29·675 | 4·425 | 8·3 | 24·4 | Nil. | 1·5 | 24·4 | .. | .. |
| July .. .. .. | 28·0 | 1·016 | 66·5 | 19·25 | 4·36 | 8·2 | 18·75 | Nil. | 2·0 | 30·0 | 0·68 | .. |
| August .. .. | 29·0 | 1·008 | 64·5 | 20·9 | 4·2 | 8·6 | 7·25 | 2·0 | 1·2 | 28·8 | 0·68 | .. |
| September .. .. | 29·5 | 1·01 | 63·0 | 20·95 | 4·2 | 8·2 | 6·5 | 2·0 | 2·0 | 28·25 | .. | .. |
| October .. .. | 30·5 | 1·01 | 71·5 | 15·81 | 4·26 | 7·8 | 7·0 | 2·2 | 1·5 | 33·55 | 0·78 | .. |
| November .. .. | 32·0 | 1·01 | 73·5 | 14·6 | 4·56 | 8·0 | 6·0 | 1·0 | 1·6 | 44·5 | 0·69 | .. |
| December .. .. | 28·0 | 1·01 | 62·0 | 16·06 | 4·27 | 8·0 | 6·0 | 1·0 | 1·2 | 34·5 | 0·92 | .. |

TABLE 24.

*Hydrology of Estuairne Fish Farm—Pond S. III.* 1960.

| *Months.*<br>(1)<br>1960. | *Temperature.*<br>(2)<br>°c. | *Specific gravity.*<br>(3) | *Turbidity.*<br>(4)<br>CM. | *PH. value.*<br>(5) | *Salinity.*<br>(6)<br>0/00. | *Oxygen cc/L.*<br>(7)<br>CC/L. | *Silicate.*<br>(8)<br>MGM/L. |
|---|---|---|---|---|---|---|---|
| January .. .. .. | 24·5 | 1·001 | 35·0 | 8·7 | 25·94 | 4·362 | 31·25 |
| February .. .. .. | 27·5 | 1·001 | 30·5 | 8·7 | 35·5 | 4·2 | 62·5 |
| March .. .. .. | 26·5 | 1·001 | 55·4 | 8·7 | 32·7 | 4·26 | 62·5 |
| April .. .. .. | 27·0 | 1·02 | 42·0 | 8·4 | 34·6 | 4·605 | 54·3 |
| May .. .. .. | 27·5 | 1·02 | 40·0 | 8·4 | 31·7 | 4·76 | 59·5 |
| June .. .. .. | 25·0 | 1·02 | 39·0 | 8·4 | 33·2 | 4·0 | 78·2 |
| July .. .. .. | 27·5 | 1·02 | 44·0 | 7·8 | 33·4 | 3·64 | 65·5 |
| August .. .. .. | 27·5 | 1·021 | 73·0 | 8·1 | 33·25 | 4·2 | 56·8 |
| September .. .. | 28·0 | 1·02 | 96·0 | 7·8 | 30·31 | 3·7 | 78·1 |
| October .. .. .. | 27·0 | 1·01 | 82·7 | 7·6 | 22·7 | 4·06 | 22·5 |
| November .. .. | 26·0 | 1·012 | 100·0 | 7·4 | 10·5 | 4·34 | 8·75 |
| December .. .. .. | 25·5 | 1·001 | 93·25 | 7·4 | 14·85 | 4·2 | 11·25 |

TABLE 25.

*Hydrology of Estuarine Fish Farm—Pond S III.* 1961.

| *Months.* | *Temperature.* | *Specific gravity.* | *Turbidity.* | *Salinity.* | *Oxygen cc/L.* | *Silicate.* | *PH. value.* | *Carbon dioxide.* | *Bicarbonate.* | *Phosphate.* | *Depth.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|  | °*C.* | '*C.* | CM. | 0/00 |  | *Mgm/L.* |  | *Ppm.* | *Ppm.* | *Ppm.* | FT. |
| January .. .. | 27·0 | 1·01 | 86·0 | 17·72 | 4·41 | 10·5 | 7·6 | 1·1 | .. | .. | 4—6 |
| February .. .. | 27·0 | 1·012 | 90·5 | 18·62 | 3·85 | 30·5 | 7·6 | 1·0 | .. | .. | 4—1 |
| March .. .. .. | 28·0 | 1·012 | 78·0 | 22·26 | 5·6 | 20·13 | 8·2 | Nil. | .. | .. | 4—½ |
| April .. .. .. | 29·5 | 1·02 | 75·0 | 25·65 | 3·62 | 50·65 | 8·4 | Nil. | 26·0 | 1·2 | .. |
| May .. .. .. | 31·0 | 1·02 | 92·5 | 24·6 | 3·5 | 30·4 | 7·8 | Nil. | 38·5 | .. | .. |
| June .. .. .. | 29·5 | 1·02 | 82·5 | 21·15 | 3·92 | 33·0 | 8·0 | Nil. | 36·6 | 0·98 | .. |
| July .. .. .. | 28·0 | 1·01 | 94·0 | 17·01 | 3·877 | 11·5 | 8·2 | Nil. | 30·15 | .. | .. |
| August .. .. | 29·0 | 1·008 | 89·5 | 20·576 | 3·25 | 17·5 | 8·4 | 2·1 | 25·0 | 0·79 | .. |
| September .. .. | 30·5 | 1·01 | 74·5 | 19·55 | 3·9 | 7·5 | 7·8 | 2·5 | 27·5 | .. | .. |
| October .. .. | 31·0 | 1·01 | 79·0 | 17·11 | 3·99 | 6·5 | 7·8 | 2·0 | 31·5 | 0·79 | .. |
| November .. .. | 28·5 | 1·01 | 85·5 | 15·25 | 4·68 | 5·6 | 8·0 | 1·6 | 45·33 | 0·78 | .. |
| December .. .. | 28·0 | 1·01 | 111·0 | 16·0 | 4·2 | 3·0 | 8·02 | 1·5 | 48·0 | 0·98 | .. |

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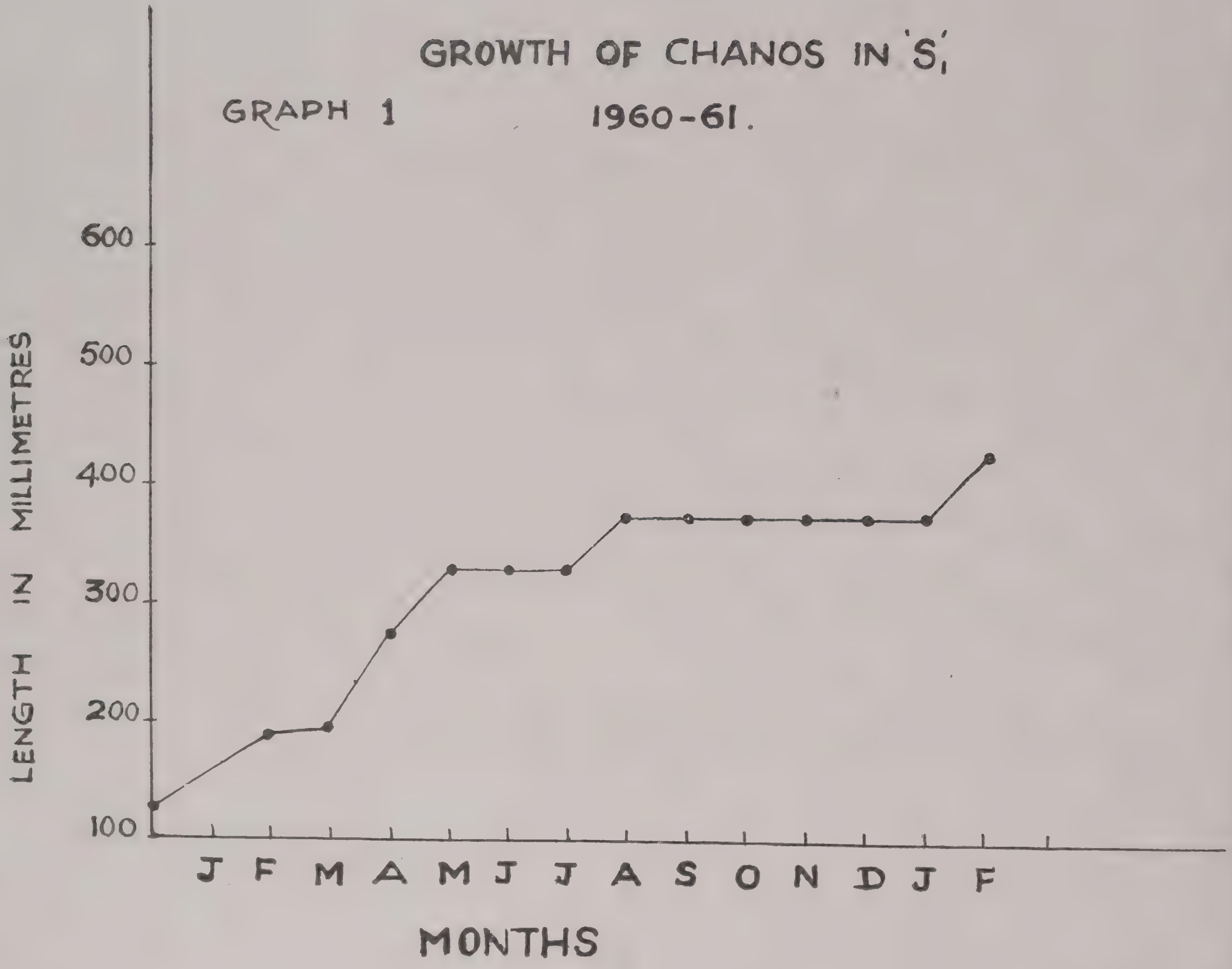
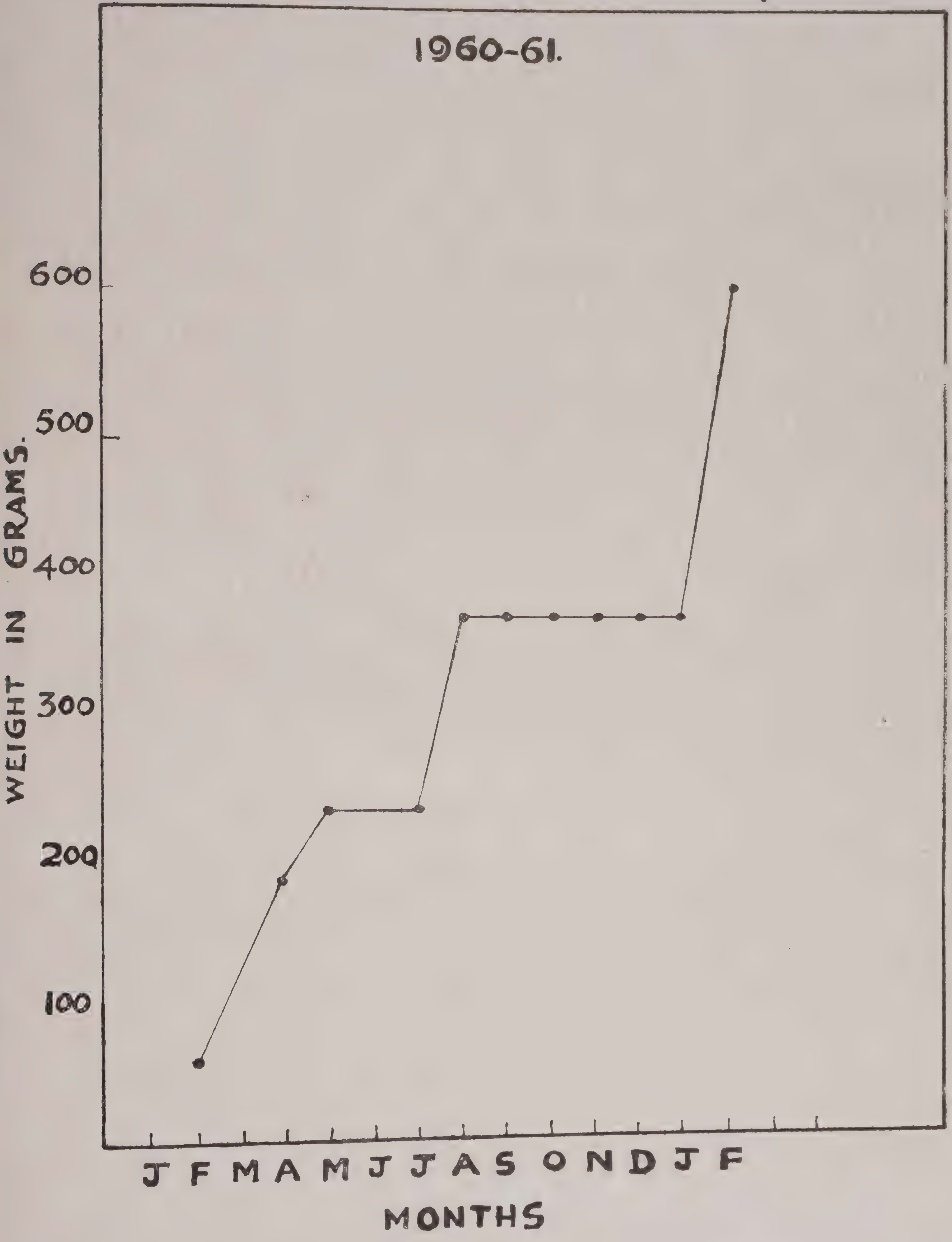
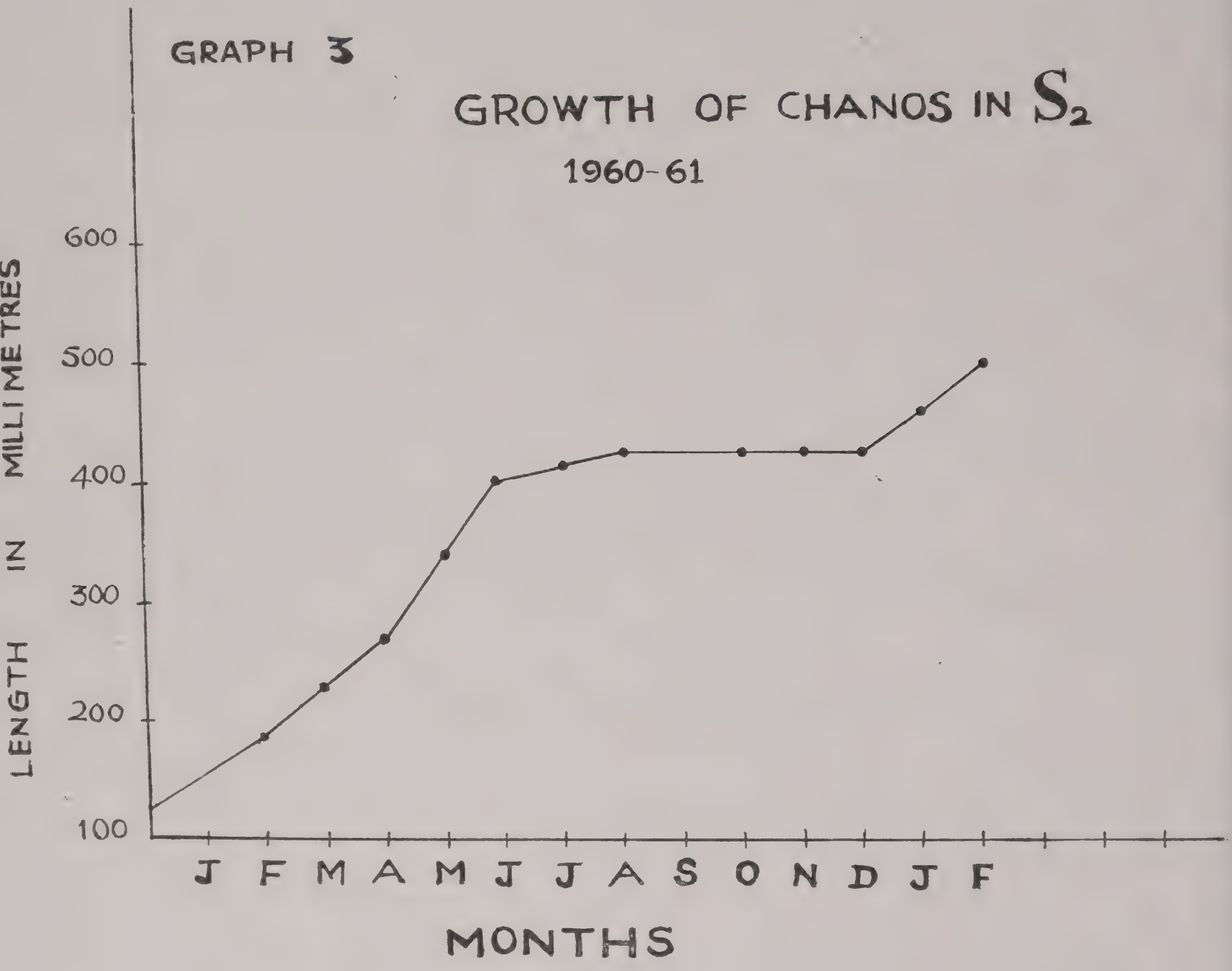
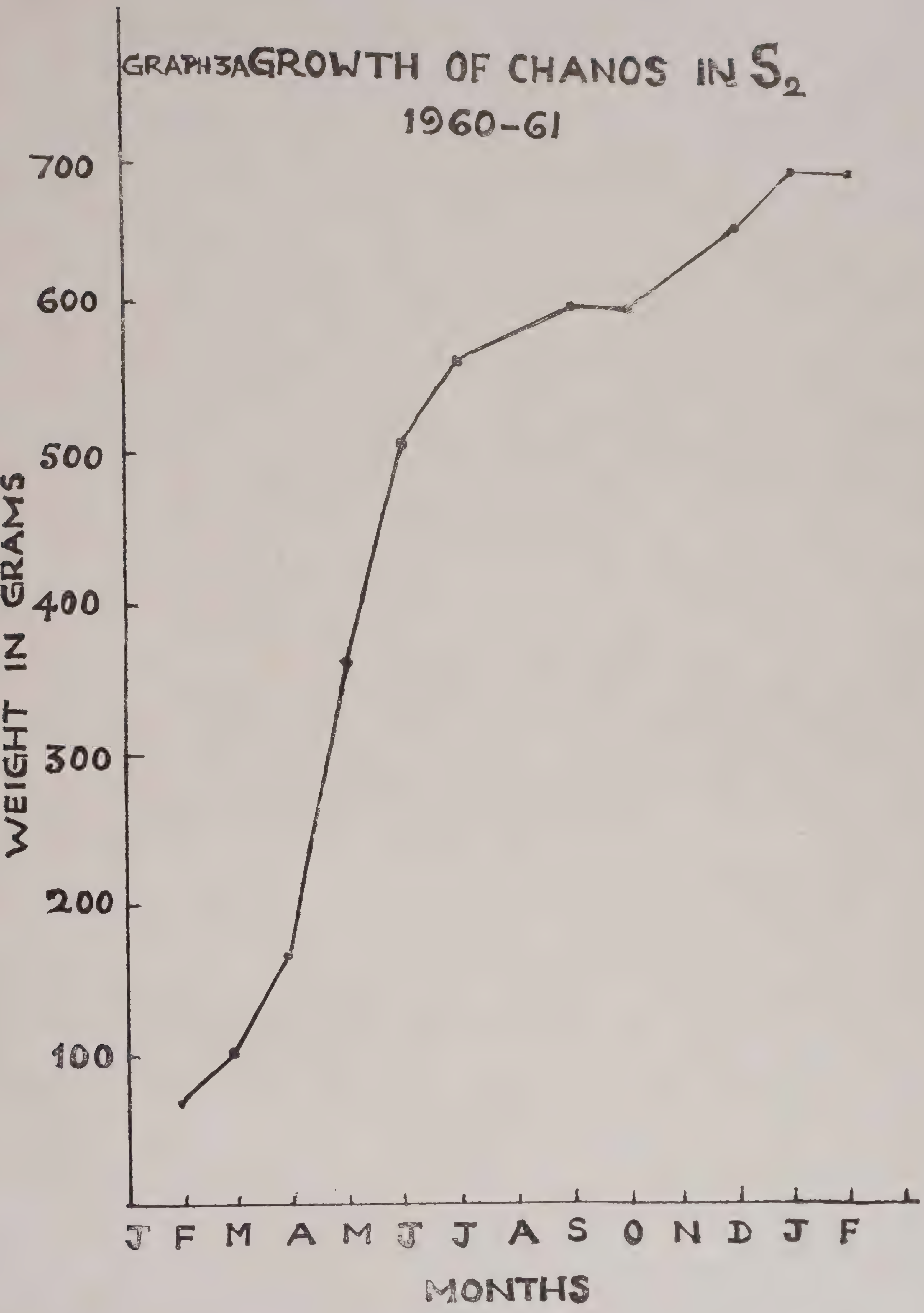

GROWTH OF CHANOS IN 'S'
GRAPH 1
1960-61.
LENGTH IN MILLIMETRES
600
500
400
300
200
100
J F M A M J J A S O N D J F
MONTHS



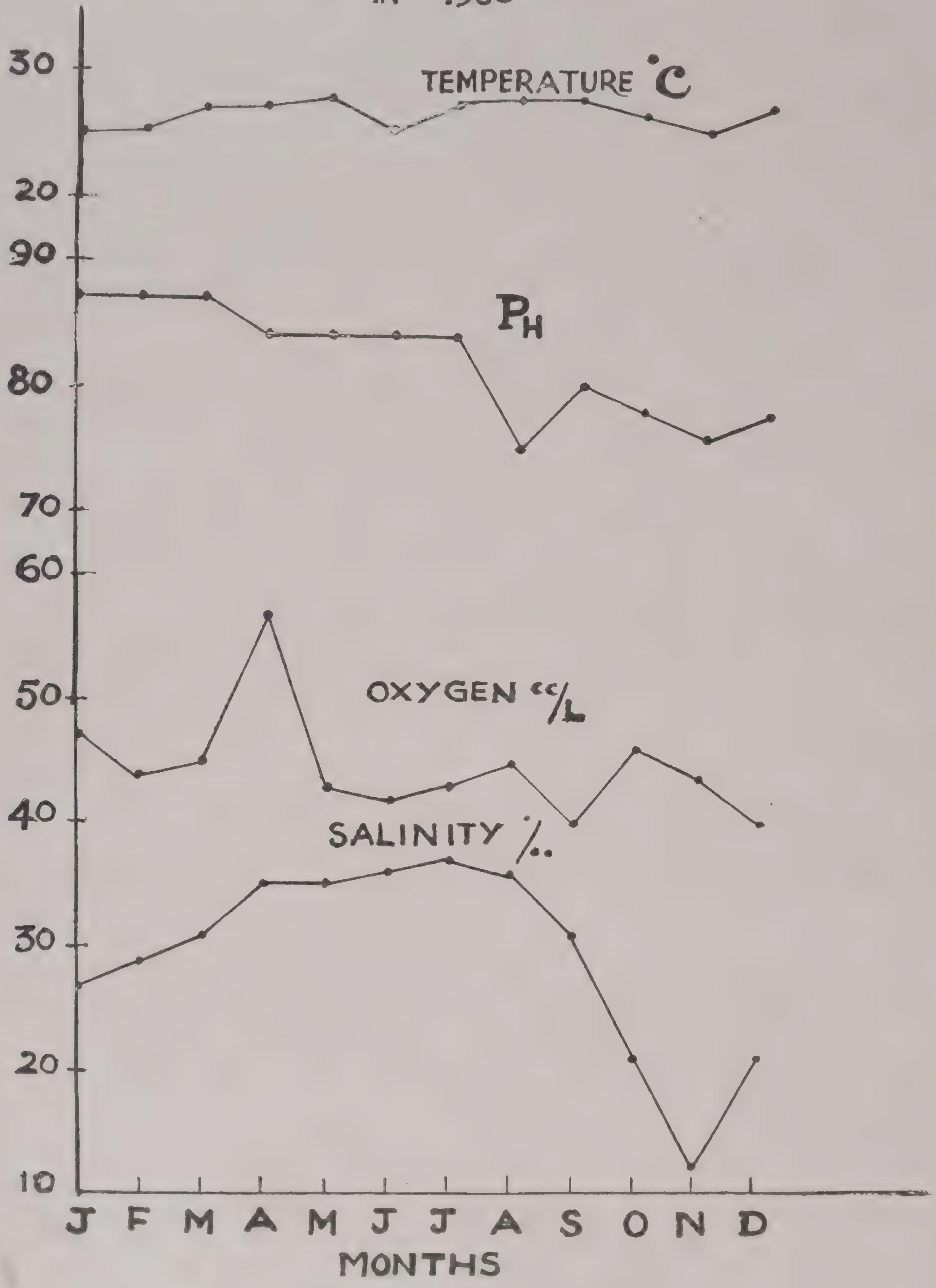
GRAPH 2 GROWTH OF CHANOS IN $S_1$

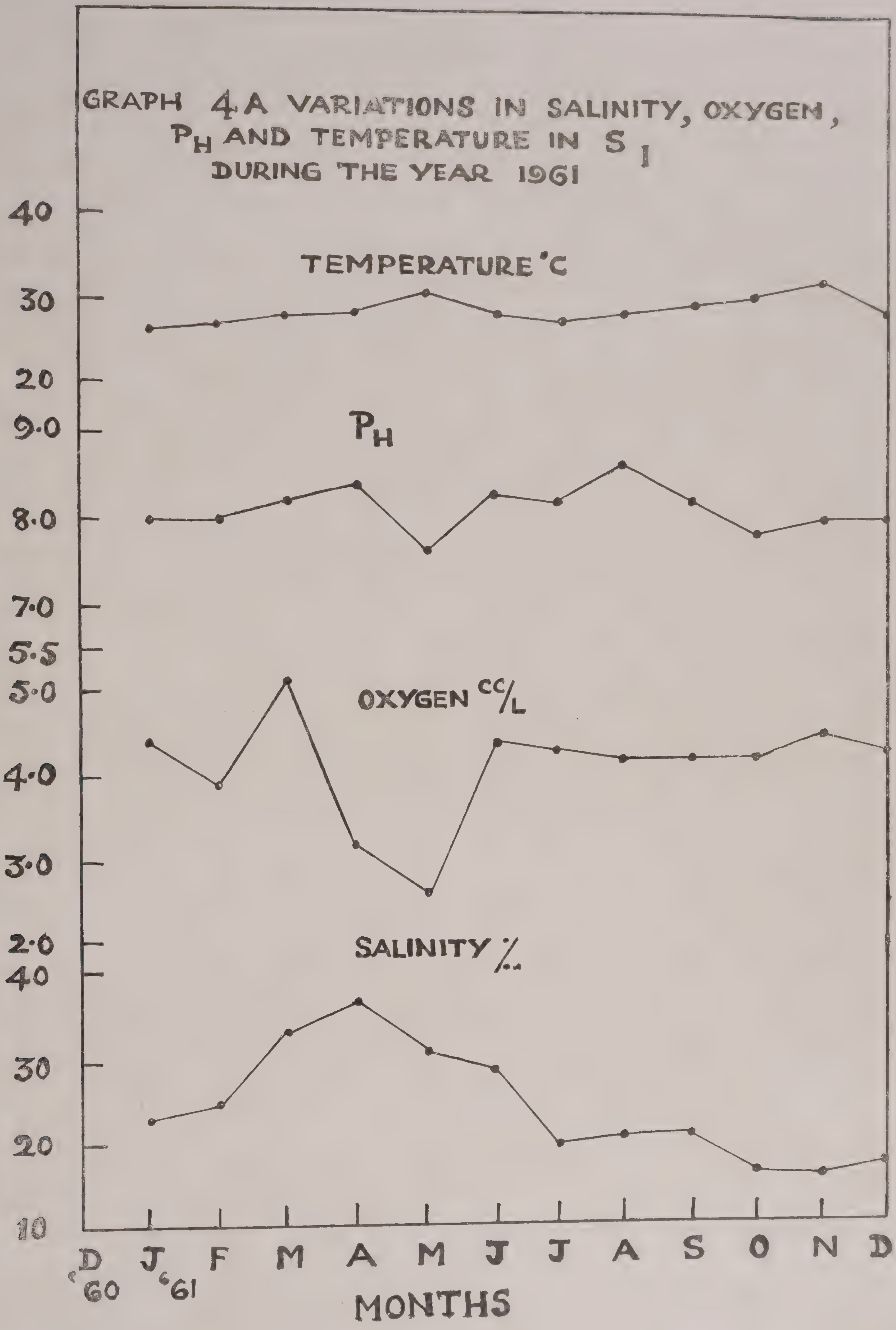
1960-61.


GRAPH 3
GROWTH OF CHANOS IN $S_2$
1960-61
LENGTH IN MILLIMETRES
600
500
400
300
200
100
J
F
M
A
M
J
J
A
S
O
N
D
J
F
MONTHS

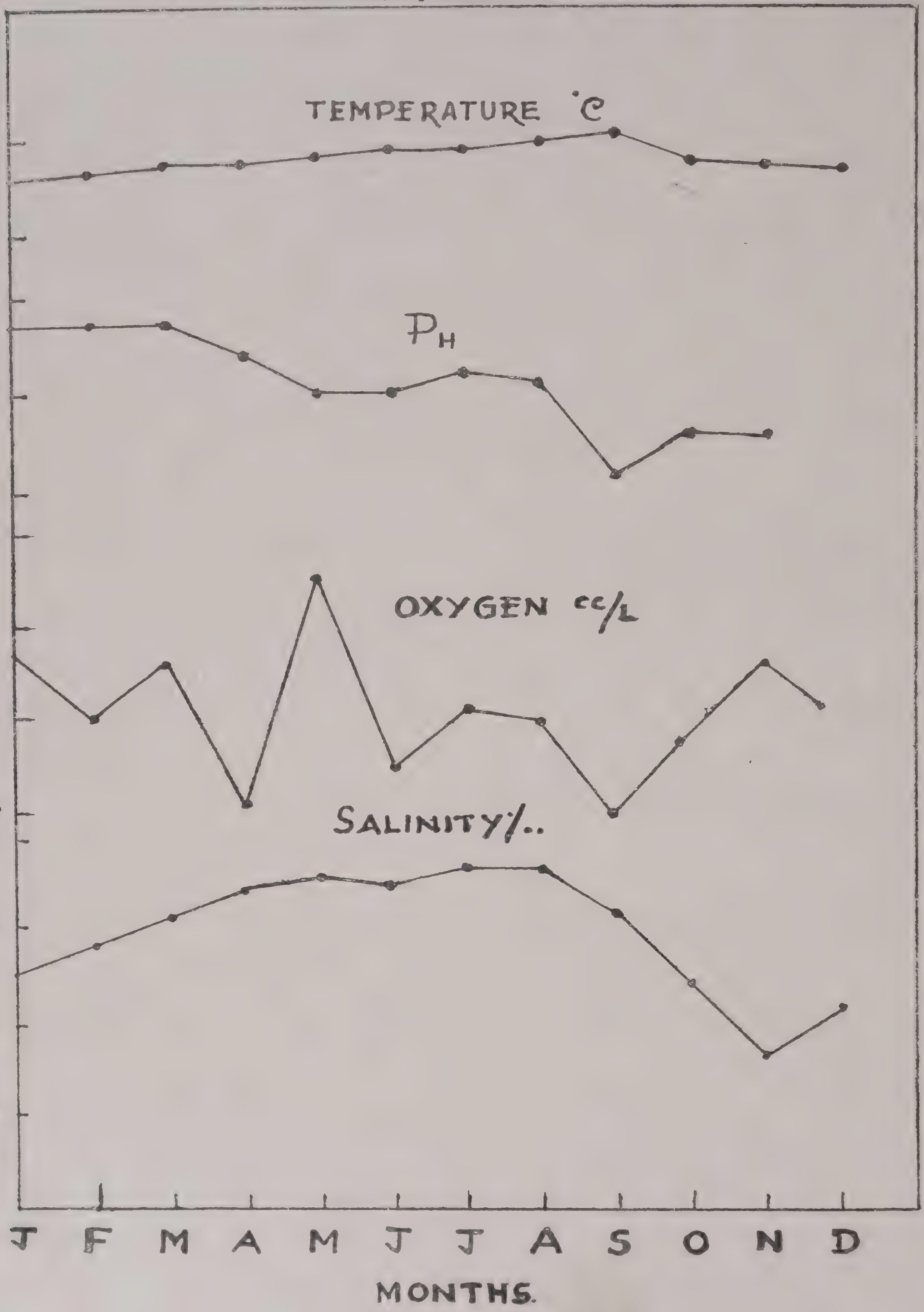

GRAPH 3A GROWTH OF CHANOS IN $S_2$
1960-61

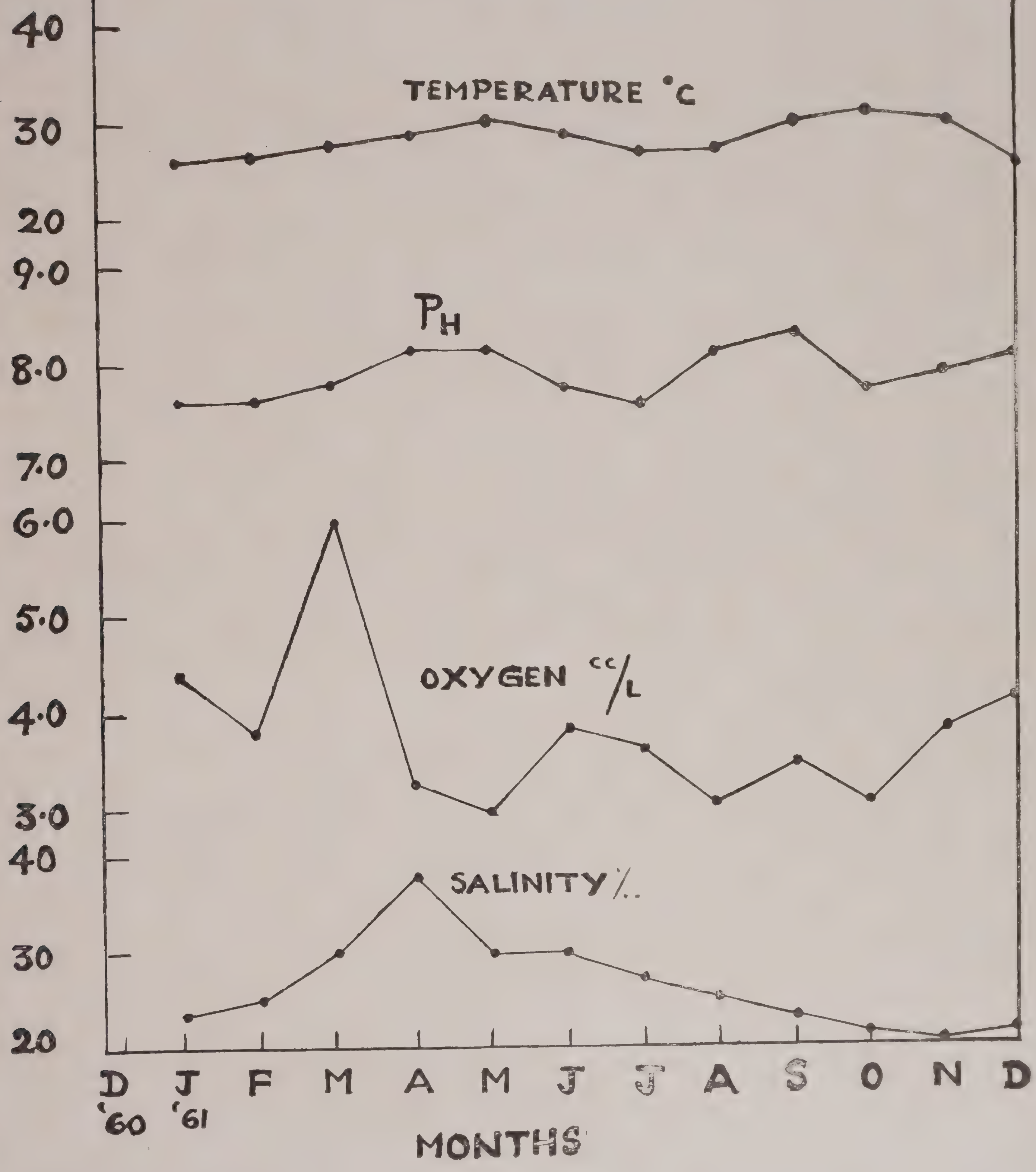
GRAPH 4 VARIATION IN POND $S_1$ IN 1960



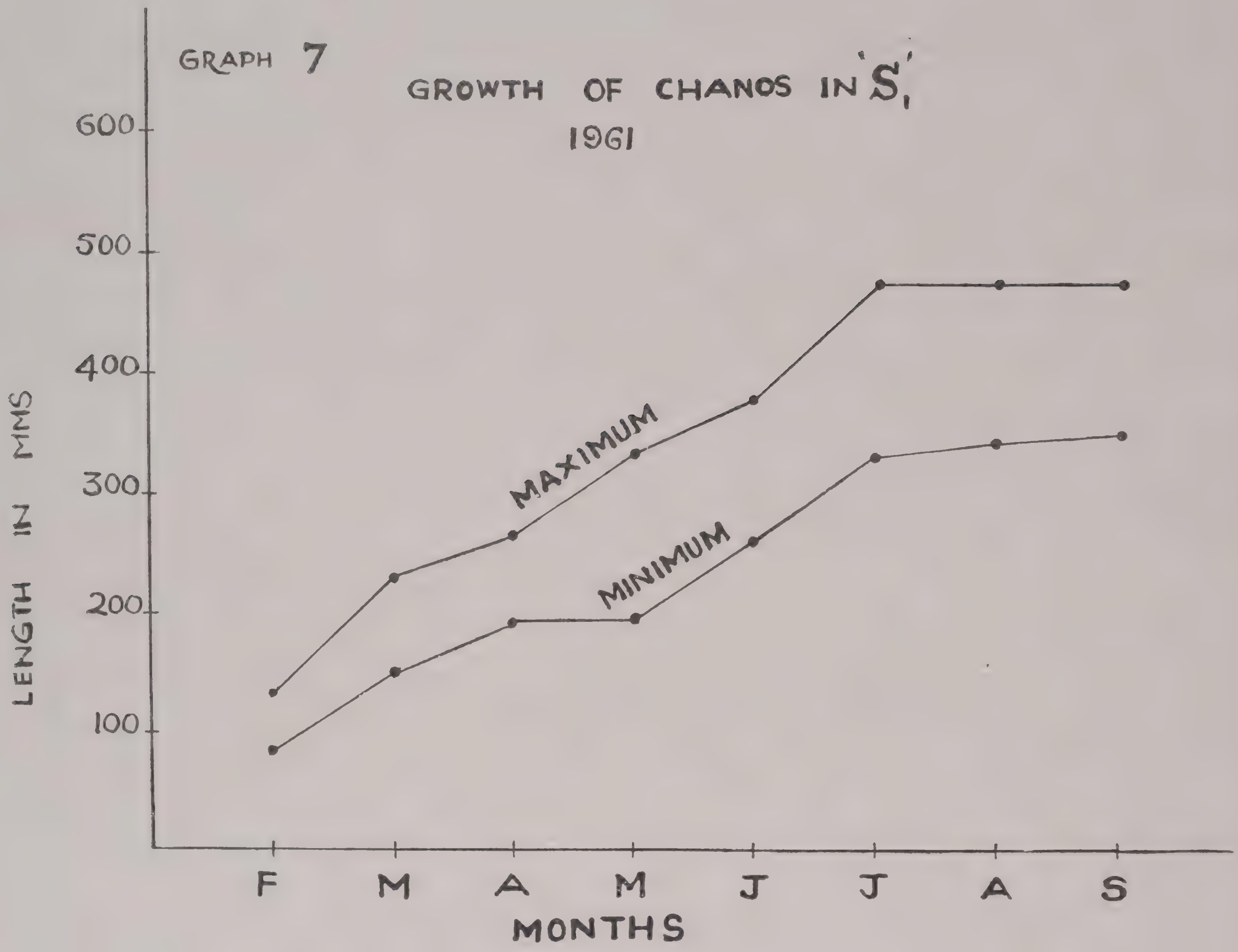

GRAPH 4A VARIATIONS IN SALINITY, OXYGEN, $P_H$ AND TEMPERATURE IN $S_1$ DURING THE YEAR 1961
TEMPERATURE °C
$P_H$
OXYGEN CC/L
SALINITY ‰
40
30
20
9.0
8.0
7.0
5.5
5.0
4.0
3.0
2.0
40
30
20
10
D '60
J '61
F
M
A
M
J
J
A
S
O
N
D
MONTHS

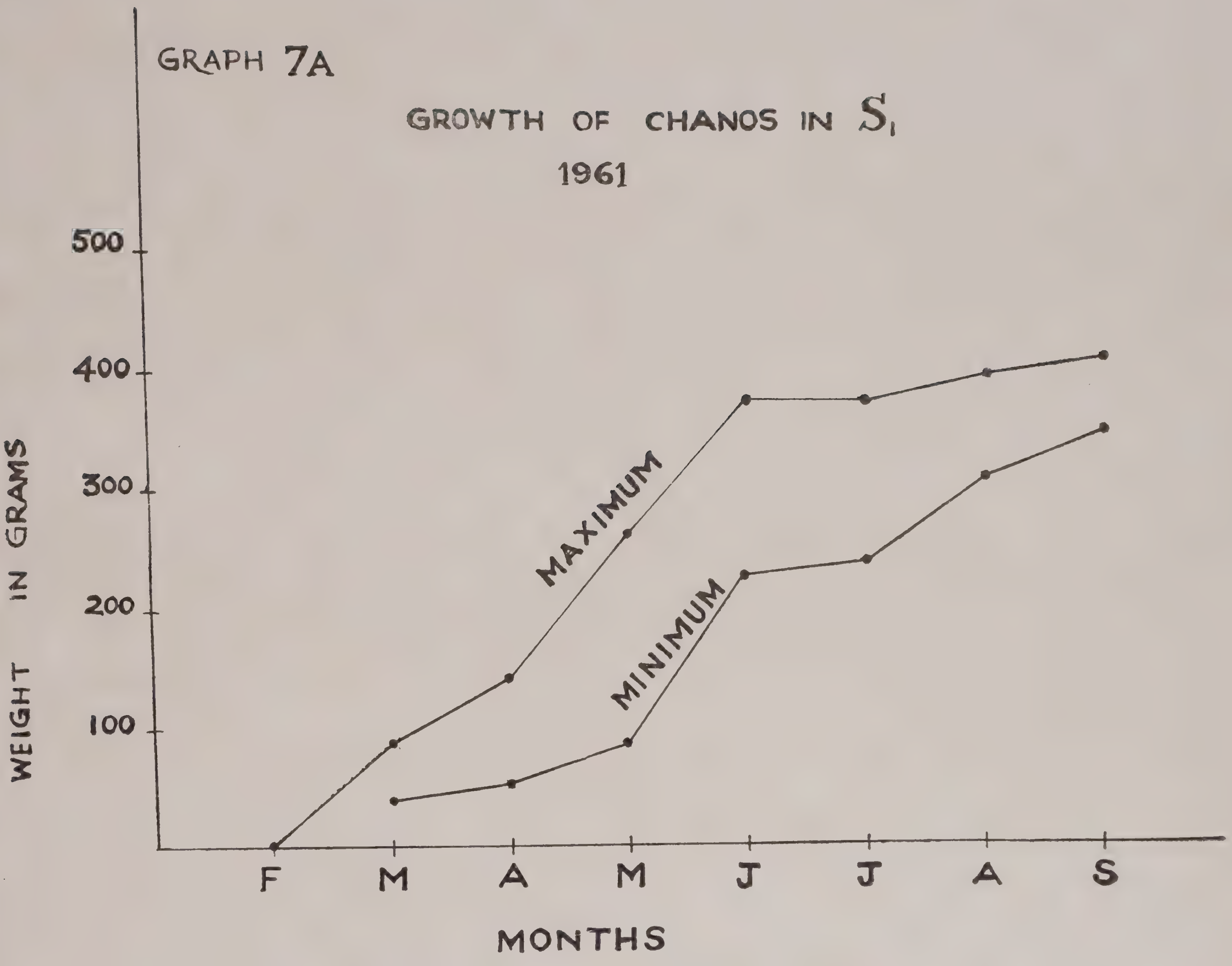
GRAPH 5 VARIATIONS IN SALINITY OXYGEN $P_H$ AND TEMPERATURE IN POND $S_2$ IN THE YEAR 1960

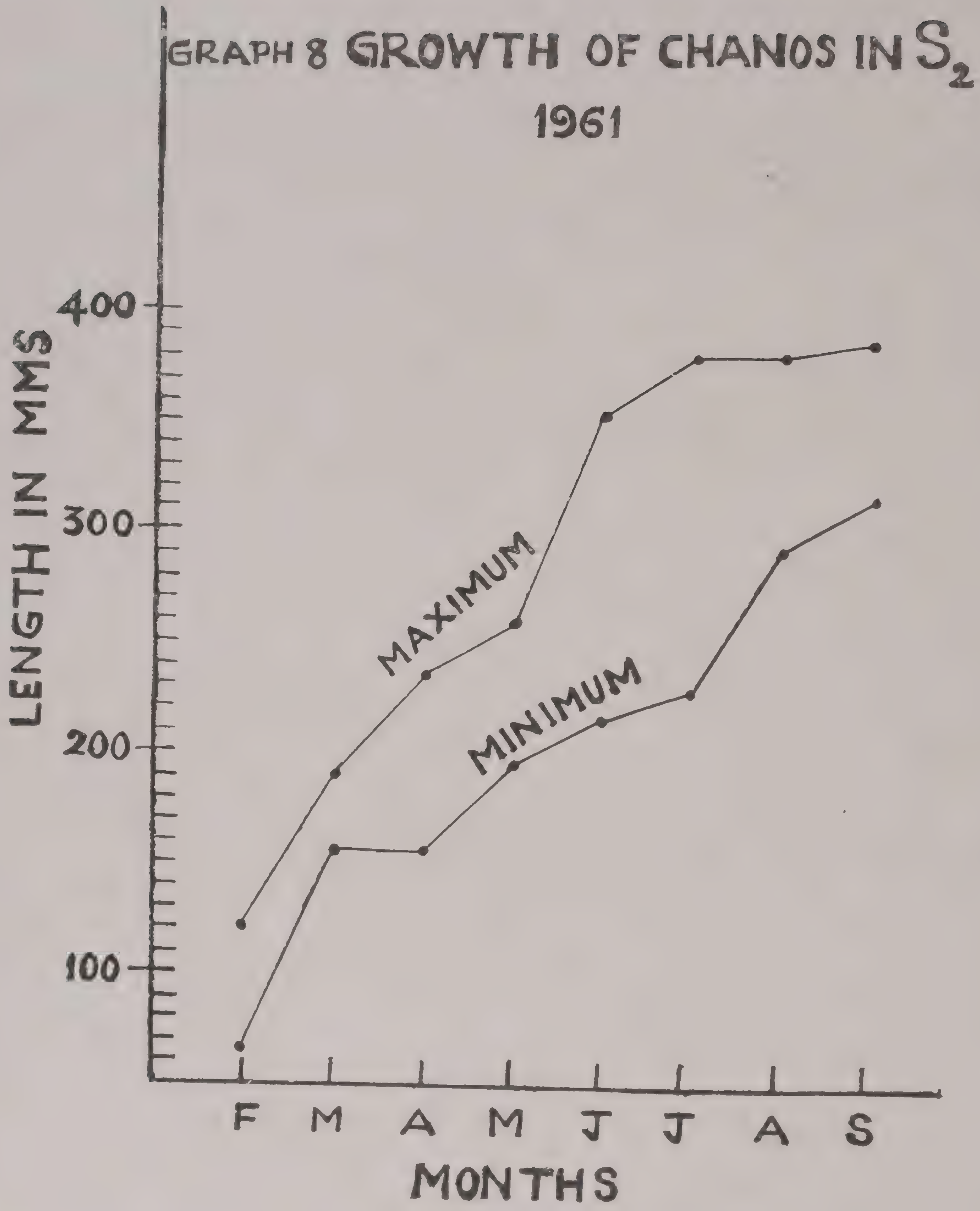




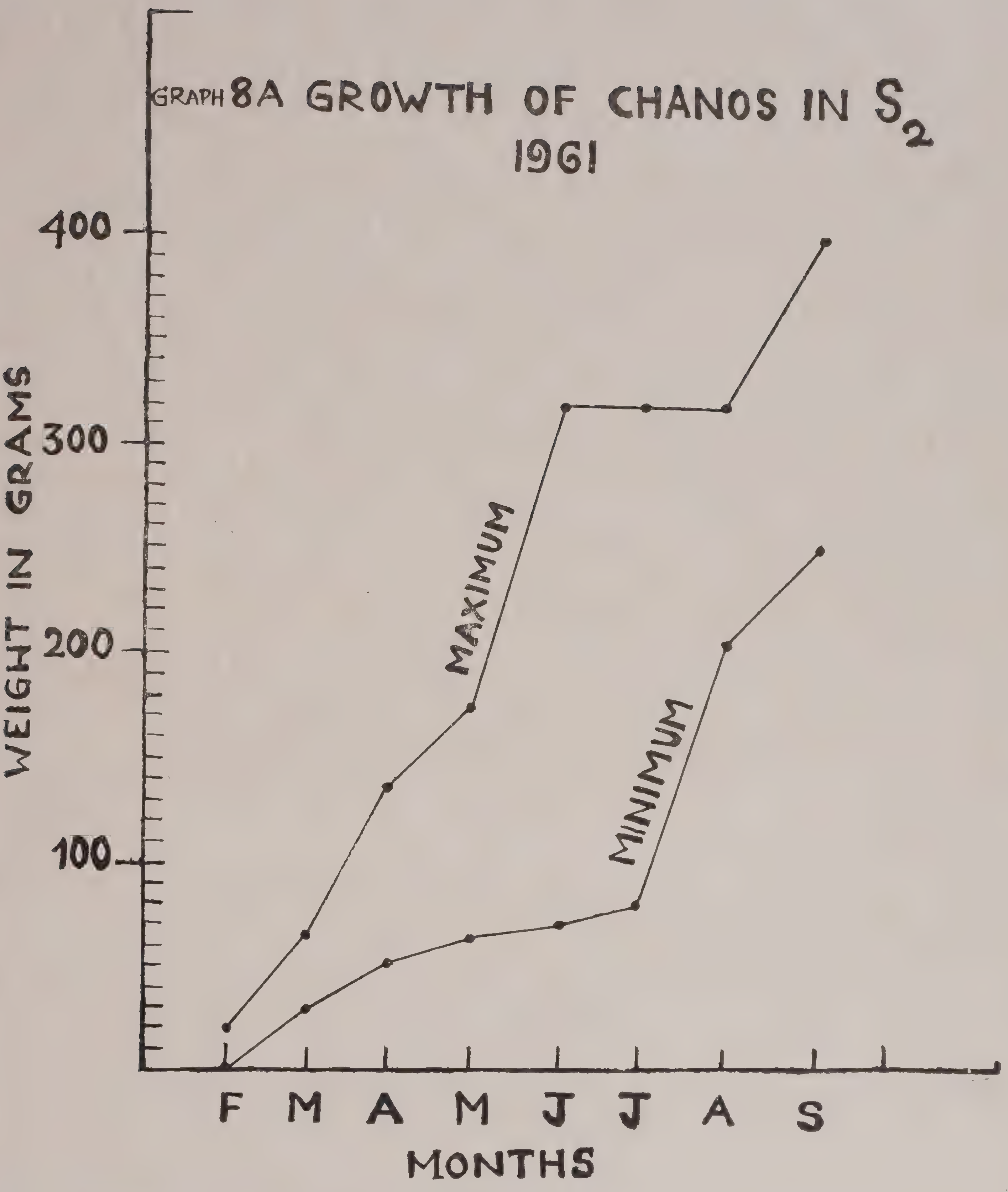
GRAPH 6 VARIATIONS IN SALINITY, OXYGEN, $P_H$ AND TEMPERATURE IN POND $S_2$ DURING THE YEAR 1961

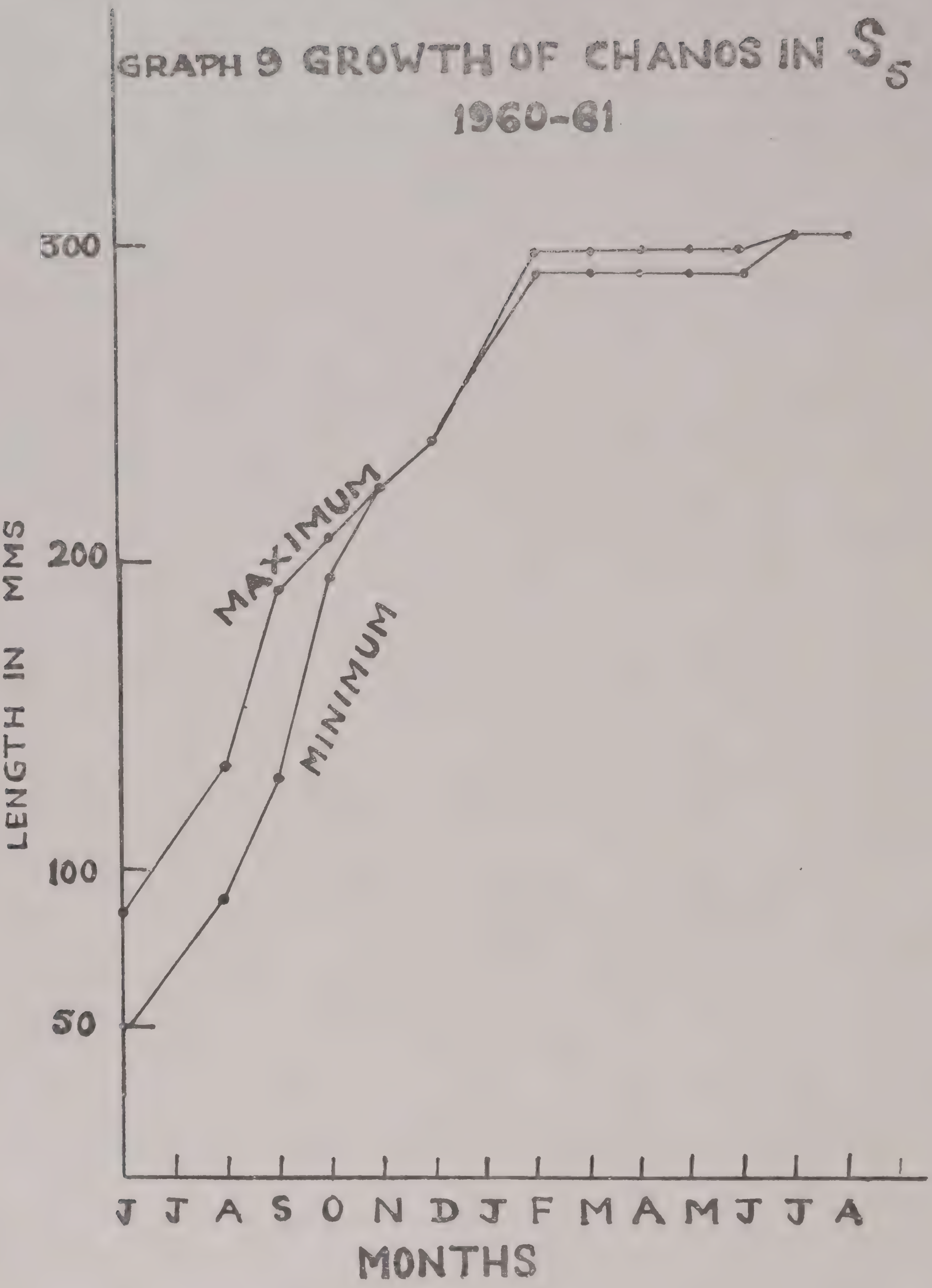

GRAPH 7
GROWTH OF CHANOS IN 'S'
1961
LENGTH IN MMS
600
500
400
300
200
100
MAXIMUM
MINIMUM
F
M
A
M
J
J
A
S
MONTHS

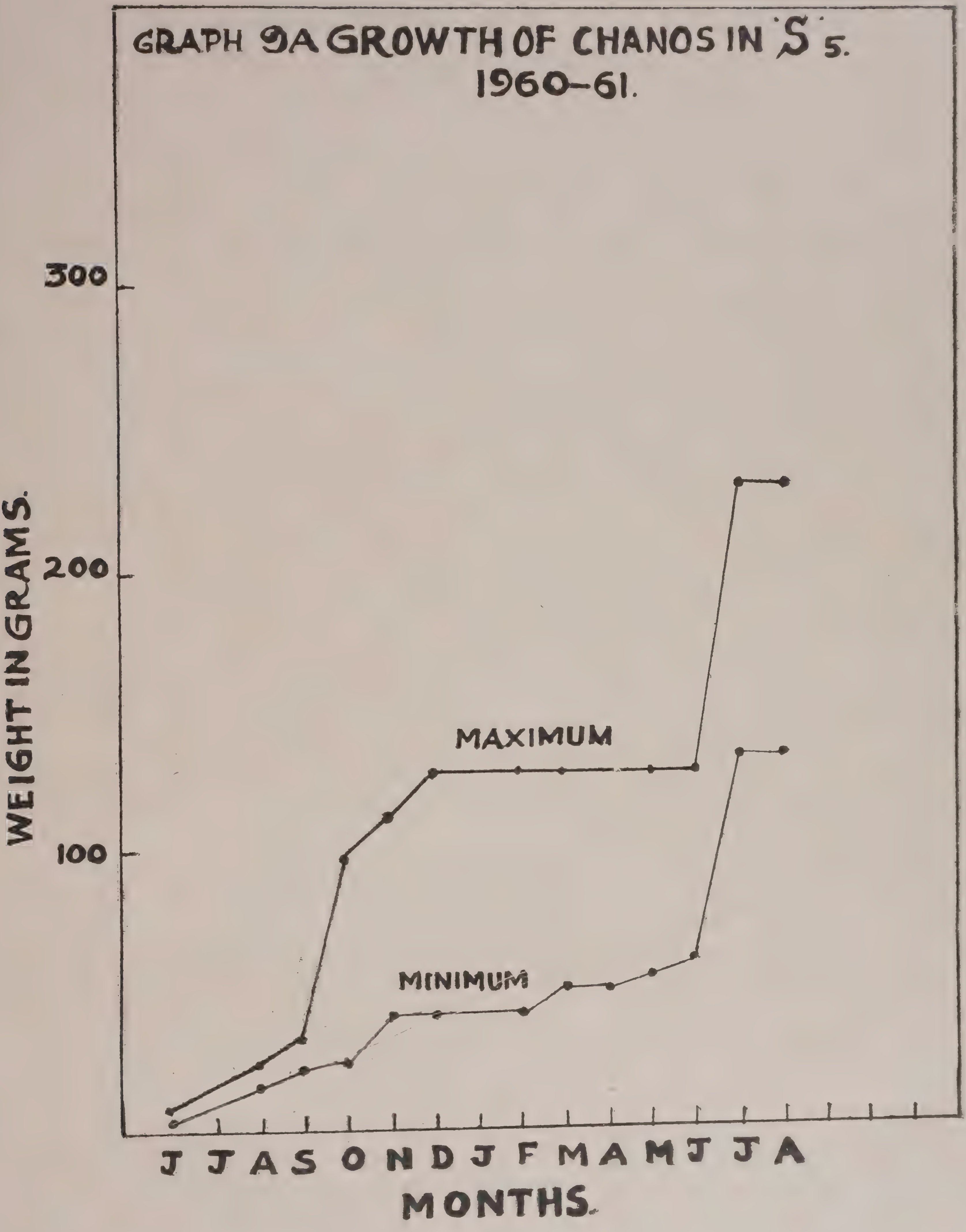

GRAPH 7A
GROWTH OF CHANOS IN $S_1$
1961
WEIGHT IN GRAMS
500
400
300
200
100
MAXIMUM
MINIMUM
F
M
A
M
J
J
A
S
MONTHS



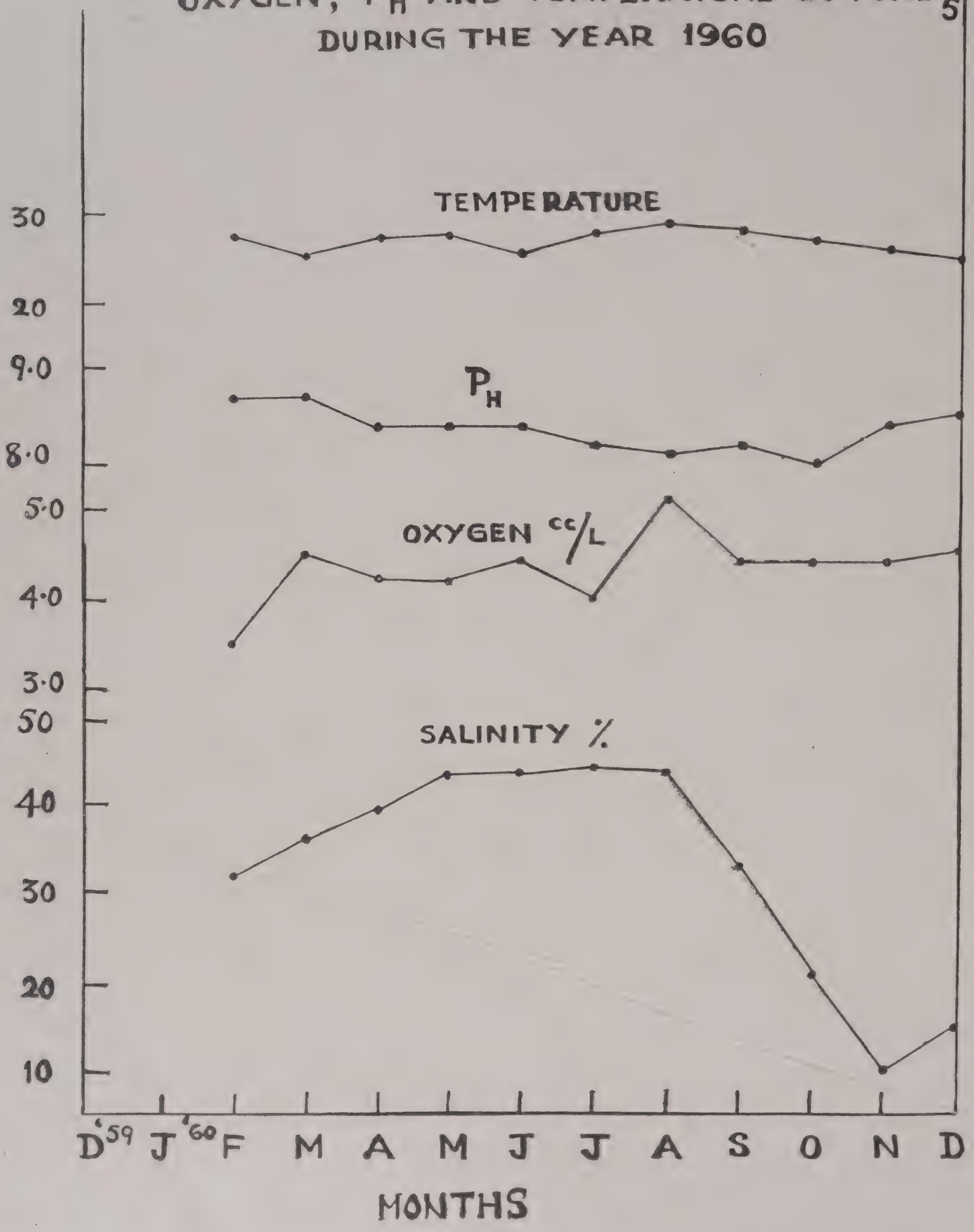
GRAPH 8 GROWTH OF CHANOS IN $S_2$
1961

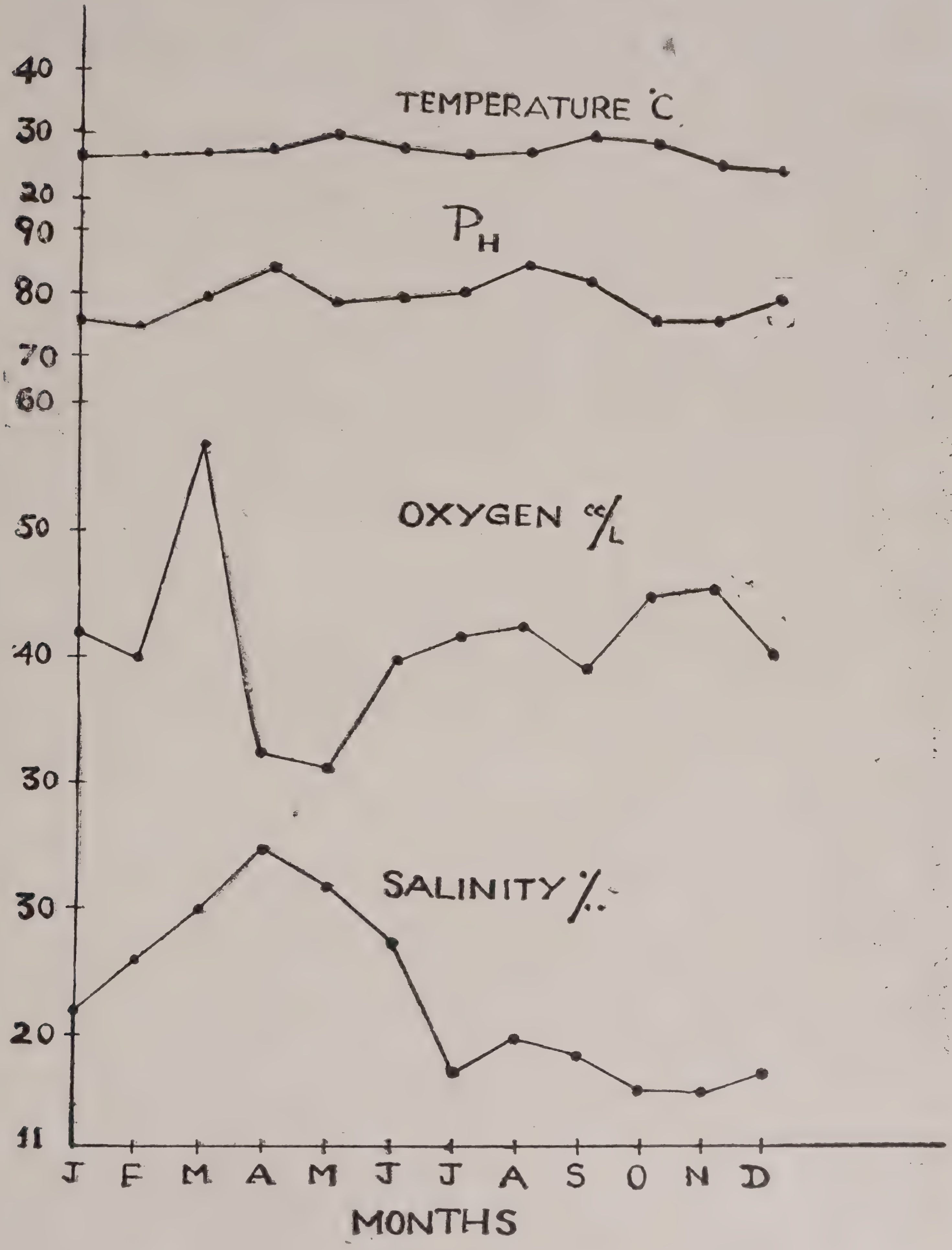

GRAPH 8A GROWTH OF CHANOS IN $S_2$
1961
WEIGHT IN GRAMS
400
300
200
100
MAXIMUM
MINIMUM
F
M
A
M
J
J
A
S
MONTHS


GRAPH 9 GROWTH OF CHANOS IN $S_5$
1960-61
300
200
100
50
LENGTH IN MMS
MAXIMUM
MINIMUM
J J A S O N D J F M A M J J A
MONTHS

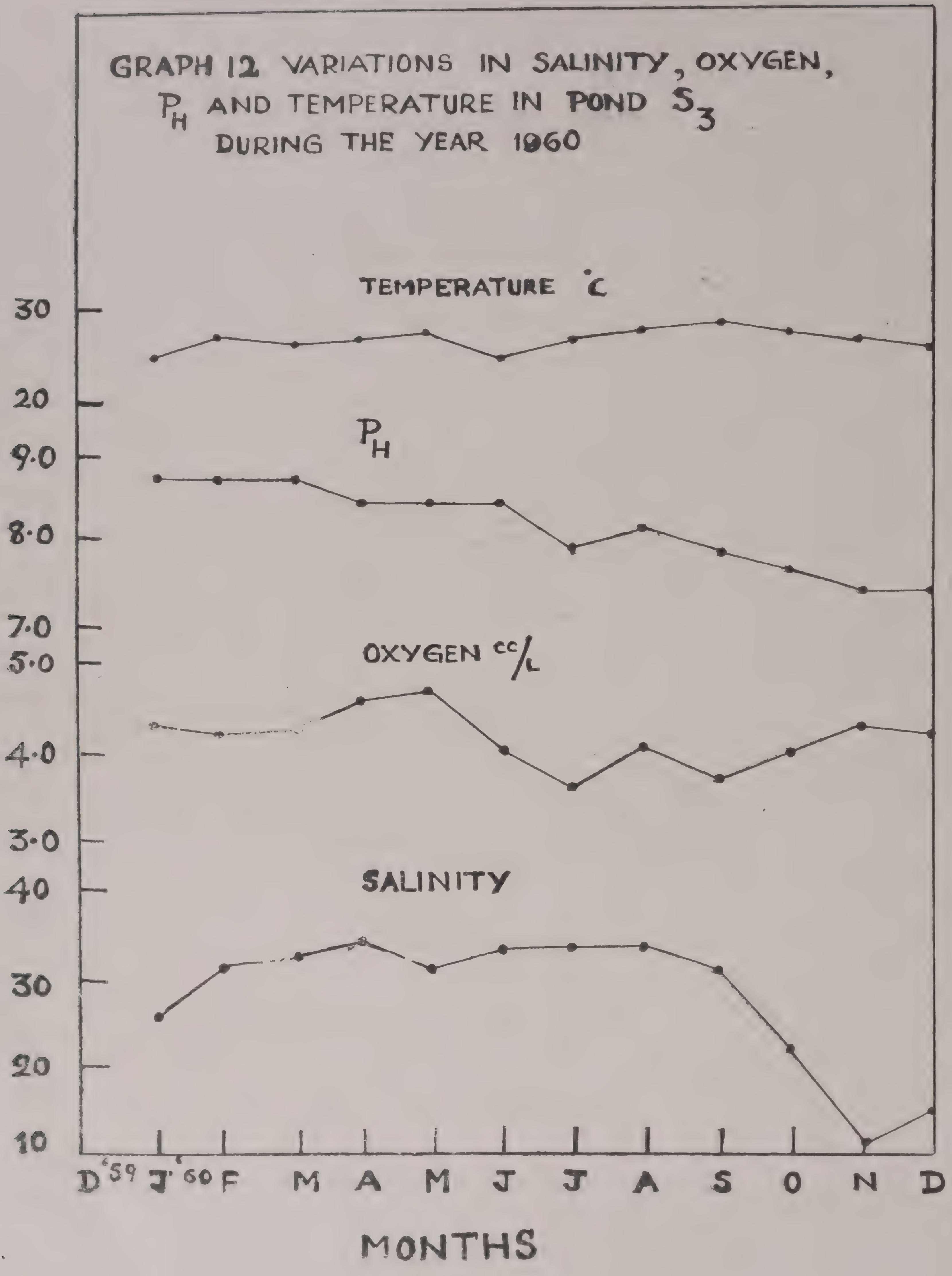

GRAPH 9A GROWTH OF CHANOS IN S 5.
1960-61.
WEIGHT IN GRAMS.
300
200
100
MAXIMUM
MINIMUM
J J A S O N D J F M A M J J A
MONTHS.

GRAPH 10 VARIATIONS IN SALINITY, OXYGEN, $P_H$ AND TEMPERATURE IN POND 5 DURING THE YEAR 1960

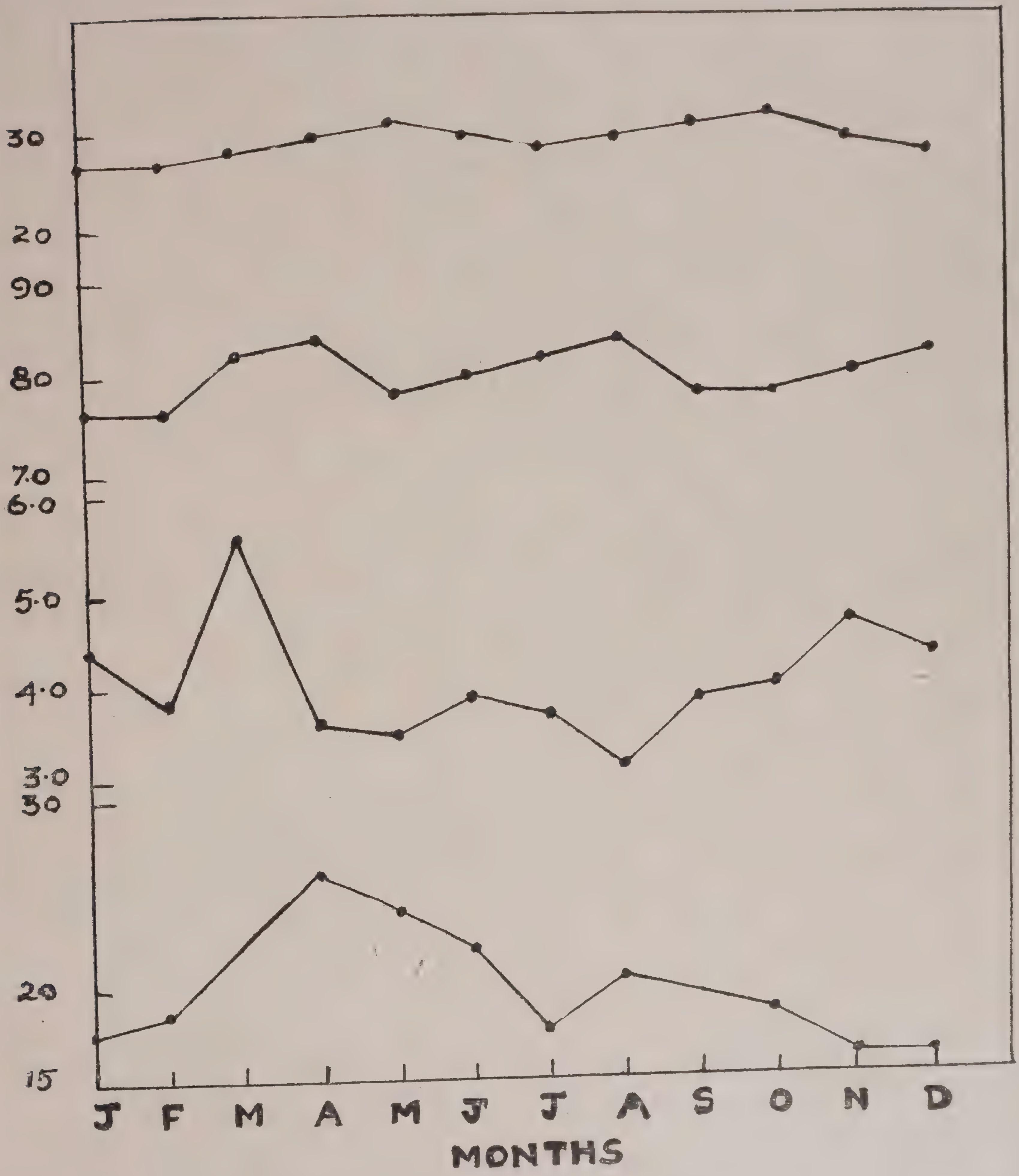


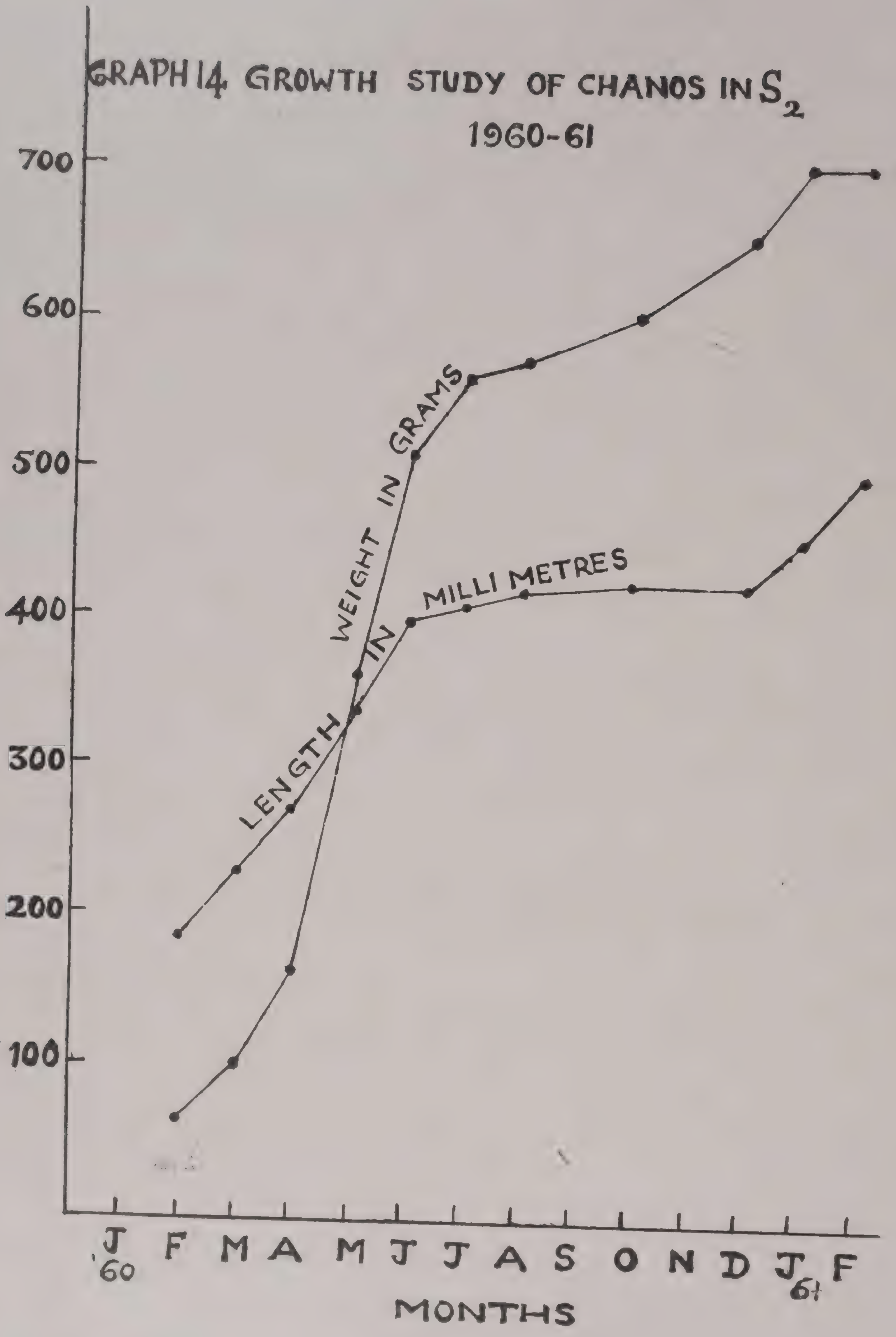


GRAPH 11 VARIATIONS IN SALINITY, OXYGEN, $P_H$ AND TEMPERATURE IN POND 5 DURING THE YEAR 1961


GRAPH 12 VARIATIONS IN SALINITY, OXYGEN, $P_H$ AND TEMPERATURE IN POND $S_3$ DURING THE YEAR 1960
TEMPERATURE °C
30
20
$P_H$
9.0
8·0
7.0
OXYGEN cc/L
5.0
4·0
3·0
SALINITY
40
30
20
10
D'59
J'60
F
M
A
M
J
J
A
S
O
N
D
MONTHS

GRAPH 13 VARIATIONS IN SALINITY, OXYGEN. PH. AND TEMPERATURE IN THE POND $S_3$ IN THE YEAR - 1961.




GRAPH 14 GROWTH STUDY OF CHANOS IN $S_2$
1960-61
700
600
500
400
300
200
100
WEIGHT IN GRAMS
LENGTH IN MILLI METRES
J
'60
F
M
A
M
J
J
A
S
O
N
D
J
61
F
MONTHS

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# OXYGEN CONSUMPTION BY FRESH WATER FISHES*

BY

A. SRINIVASAN, FRESH WATER BIOLOGICAL STATION, BHAVANISAGAR.

## Introduction

With the intensification of fish cultural activities throughout India, collection and transport of fish seed and fingerlings as is assuming importance. In many cases the seed collection centres and ponds to be stocked with fish seed are separated by long distances, requiring transport over long periods of time under varying temperature and physico-chemical conditions. It would be therefore of practical importance to have some knowledge of the oxygen consumption by different species of fish. In Madras State mostly early and advanced fingerlings are transported for stocking and hence most of the experiments were performed with these. The results are also of ecological application in indicating the survival of fish under varying conditions of oxygen content and stratification in pieces of water.

Oxygen consumption by fish is a function of its metabolic activity. The properties of fish blood hæmoglobin play an important part in oxygen transport and oxygen consumption (Shepard 1955, Fish 1956, Black 1955). The effect of temperature on respiration has been studied by Downing and Merkens (1957), Job (1955), Pritchard (1955) has reported on the oxygen requirement of some baitfishes. Bose (1949) carried out experiments on oxygen requirements of some economic carps of India. Motwani and Bose (1957) determined the oxygen consumption by the fry of *Labeo rohita,* a major carp of India. Unlike in Bengal and Orissa, in Madras State fry collection and transport is not so important as that of fingerlings and hence the transport of the latter is a problem. Oxygen consumption by some of the economic and uneconomic "Weed fish" have been determined and the results are reported hereunder.

## Material and methods

The fish fingerlings (or fry), after collection from sources, were kept in small cement cistern, for a few days and were transported to smaller containers, a day prior to the commencement of the experiment and starved. The experiments were performed by "sealing" the fish in aspirators or bottles or by using a layer of liquid paraffin in aquarium jars (Viswanathan & Tampi, 1951), (Moore, 1942). Oxygen was determined by the unmodified winkler's method (A.P.H.A. 1956). The duration of experiments was for a fixed period of one or two hours in "sealed bottle" experiments but in the case of aquarium jars layered with paraffin, the experiments were prolonged and determination of oxygen was carried out every hour by withdrawing water by a siphon arrangement. Rate of oxygen consumption during successive hours could be studied in these experiments. The "asphyxial level" was fixed as the oxygen content in mg/L at the time the fish, after critical gasping movements, upturns, drops down and does not move further.

Oxygen consumption has been calculated per unit weight of the body. The fish were delicately pressed with absorbant towel to remove surface moisture and weighed. In the case of fry (for e.g., Chanos), the method of Motwani and Bose (1953) was more useful, though even thus, wiping each fry was difficult. "Group effect" was studied by using different numbers of fish of similar size in a container of idential size and shape. A number of experiments were carried out to find out the changes in pH and carbon-di-oxide content before and after the experiment and it was found there was just very little change (0·2 units) in these even after considerable period (4 hours).

## Results

Oxygen consumption by some fresh water fishes under laboratory conditions is tabulated in Table No. I. Oxygen consumption rate differs from species to species. *Cirrhina cirrhosa,* a very active fish consumes more oxygen than other carps. But oxygen consumption is greatest in the cichlid fish *Tilapia mossambica.* The scale carp consumes very low quantities of oxygen. Golden carp which is usually not very active consumes less oxygen than mirror carp at comparable temperature.

Asphyxial levels of some of the fish indicated in the Table show that Mirror carp has low asphyxial level. For example at 20·4°C it was just 0·40 mg/1 (4·261 per cent saturation). *Tilapia* fry which consume more oxygen than other fish had a high asphyxial level of 0·85 mg/1 of oxygen (10·9 per cent saturation) while the adults of the same species were asphyxiated at 0·60 mg/1 (7·667 per cent saturation).

## Volume effect

When comparing oxygen consumption by different species, the volume, or rather the amount of dissolved oxygen of water used has to be uniform. It has been found (Table No. II) that for the same fish, oxygen consumption rate increases as the volume of water increases. With decrease in volume of water, oxygen consumption correspondingly drops. When the concentration of total quantity of oxygen present is high, oxygen consumption is also greater. This is true only in the "Oxygen dependent" zone and this effect was not seen in the "non-dependent zone".

## Size effect

Oxygen consumption per unit weight of fish and time is influenced by the size (weight) of fish. From the data available in Table No. III, it could be seen that fry, per unit weight consume more oxygen than adult fishes.

## Group effect

Quite a number of workers have established the occurrence of "Group effect" in the respiration of fishes. In the same volume of medium, fish consume per unit weight, more oxygen when present singly or in pairs, than when present in groups. This has been borne out by the data in Table No. IV. Other conditions such as temperature, size of fish, etc., were maintained the same. The larger the number of the fish the lower the consumption per fish.

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### Effect of tranquilizers and narcotizers on oxygen consumption by fish

Oxygen consumption in fish being a function of its metabolism, the activity of fish influences oxygen consumption. It is well-known that the thyroid controls the metabolism and hence thyroid depressants may be expected to reduce oxygen consumption. Results on the effect of Thiouracil, Urethane and Veronal (Barbitone) are presented in Table No. V. Below 20 p.p.m. Veronal did not show marked reduction in oxygen consumption. Urethane and Thiouracil exerted positive effect at 10·0 p.p.m. It was found that Thiouracil in higher concentration interferred with oxygen determination.

### Effect of salinity

In transplanting marine or estuarine fish it would be useful to know the oxygen consuming capacity in media of higher and lower salinity. Two experiments were carried out with 36 *chanos* fry. In two hours the oxygen consumed by them in mg. are given below :—

| | 100 *per cent sea water.* | 50 *per cent sea water.* |
|---|---|---|
| I Oxygen consumed by 36 fry in 2 hours in mg. | 4·813 | 3·538 |
| II Do. | 7·525 | 4·963 |

With the lowering of salinity there is a distinct reduction in oxygen consumption. However it is felt more experiments are needed in this line, and are being pursued.

### Discussion

In experiments on oxygen consumption by fish the pH of the medium, presence of free carbon-di-oxide, etc. (Basu 1949) may affect it. Experiments performed over prolonged periods in "closed" systems therefore do not yield correct results. In our experiments the experiments were carried out for one or two hours during which there is no marked change in the medium. Basu (1951) has shown that in the case of fry of *Labeo* spp. the toxic limit of carbon dioxide is 75 p.p.m. at an oxygen concentration of 1 p.p.m. He had further shown that per unit weight of body, mrigal consumes more oxygen than Catla or Rohu. In our experiments, it is found that golden carp and scale carp consume very low amounts of oxygen, while an active fish like *Cirrhina cirrhosa* consumed higher quantities of oxygen. Mirror carp was found to have a lower asphyxial level than the other fish. This must have a bearing on its transport. In terms of percentage of oxygen saturation, the asphyxial levels are generally below 10 per cent saturation. Downing and Merkens (1957) determined the highest oxygen tension killing fish, for various species and the results varied from species to species. This could be explained on the basis of the work of Fish (1956) on the oxygen dissociation curves of fish blood hæmoglobin. This has also been stressed by Shepard (1955) who found that the capacity of the blood for oxygen transport rapidly decreases as the oxygen uptake is reaching a low level.

Though no attempt has been made to study the effect of temperature on oxygen consumption, results obtained by performing the experiments on Mirror carp and scale carp in Ooty, a hill station (temperature range 18·4—20·6°C) and at Bhavanisagar (26·6 to 32·0°C) shows a clear difference. Oxygen consumption by fish of comparable sizes is greater at the higher ones than at lower temperature. As has been pointed out by Basu (1951), the advantages of transporting fish seed at 20°C are obvious and this can easily be achieved by a small quantity of ice. At this temperature the asphyxial level for Mirror carp was only 0·40 mg/l (4·26 per cent saturation). Oxygen consumption was highest in Tilapia. Fry, just as they consume more oxygen have higher thresholds of oxygen for asphyxiation, as it seen from the fact that *Tilapia* fry the asphyxial level is 0·85 mg/l (10·9 per cent saturation). while for the same adult it is 0·60 mg/l (7·667 per cent saturation). Vaas (1951) found that big fishes "held out longer than small fishes" evidently because of lower asphyxial levels. In confirmity with our results, Shepard (1955) similarly noted that "fry maintained a higher rate of oxygen consumption per unit weight than did either of the other groups. In turn, fingerlings removed proportionately more oxygen than did the yearlings. Large fish did not take up oxygen at as rapid a rate per unit weight as smaller fish." Though Keys (1931) also found larger fish more resistant to asphyxiation due to smaller oxygen demand per unit weight of larger fish, than smaller fish, Pritchard (1955) could not confirm the results. Moore (1942) however observed that larger fishes survived critical oxygen concentration longer than smaller individuals of the same species. Job's work on chanos also shows size effect (Job 1957, p.308) Saha *et al* (1956, p. 131 TableNo. II) tabulated the oxygen consumption by fry of different sizes and weight. It is clear that per unit weight of body per hour, larger fish consumed less oxygen than smaller fish. This is further confirmed by them (i.e., p. 132 Table No. IV).

The "Group effect" noticed by us was also observed by Pritchard (1955) who thinks that fish are more quiescent when tested in groups rather than individually. When large numbers of fish were used the overall level of metabolism is lower. This is seen in TableNo. IV striking results being obtained with *Tilapia* and *E. maculatus*. The above view is supported by Shuett (1933), Schlaifer (1938) and Geyer and Mann (1939). The results presented by Viswanathan and Tampi (1952, p. 152—153) also indicate the operation of "Group effect". This has a bearing on transport of live fish. At present, the number of fish that can be transported in a definite volume of water is arbitrarily chosen. Since the rate of oxygen consumption decreases when fish are present in groups, it can be reasonably expected that larger numbers can be transported, provided of course the residual oxygen in the medium is not reduced to the lethal asphyxial level.

Drugging of fish to enable safer transport seems to be a promising prospect (Anon. 1954, 1955 and 1957). In our experiments, we found that Thouracil, Urethane and Veronal markedly depressed oxygen consumption by fish. Field trials under the influence of these hyponotics may yield very useful data and are being planned. Zaks and Zamkova (cited Shepard 1955) also noted a decrease in oxygen uptake under the influence of Thiourea.

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## Table No. I.

*Oxygen consumption by certain Fresh Water Fishes (Mg. per hour per gram weight of body).*

| *Fish.* (1) | *Temperature range oc.* (2) | *Size range cms.* (3) | *Oxygen consumed.* (4) | *Asphyxial level mg/L oxygen.* (5) | *Remarks.* (6) |
|---|---|---|---|---|---|
| *Labeo fimbriatus* | 24·8 | 8·0–9·0 | 0·18 | 0·60 (9·59)* | .... |
| | 26·8 | 11·0 | 0·24 | 0·9 (10·72) | .... |
| *Cirrhina cirrhosa* | 27·2–40·8 | 6·3 | 0·38–0·46 | .. | .... |
| | 26·6 | 10·9 | 0·35 | 0·74 (6·987) | .... |
| *Catla catla* | 28·6 | 28·6 | 0·11 | .. | .... |
| | 28·0 | 12·2 | 0·27 | .. | .... |
| *Barbus carnaticus* | 30·4–30·8 | 11·8–12·5 | 0·19–0·27 | 0·70 (8·03) | .... |
| | 31·4 | 6·5–10·1 | 0·47–0·48 | 0·70 (8·884) | .... |
| *Barbus machocola* | 28·2 | 10·0 | 0·43 | 0·60 (7·64) | .... |
| *Cyprinus caprio var* (specularis). | 17·4–19·4 | 2·5–3·5 | 0·23–0·32 | .. | .... |
| | 18·4 | 8·2 | 0·13 | .. | .... |
| | 19·8 | 8·2 | 0·20 | .. | .... |
| | 20·0–20·6 | 4·8–5·6 | 0·27–0·34 | 0·40 (4·26) | .... |
| | 26·6–32·0 | 5·8–17·2 | 0·24–0·38 | 0·35 (4·20) | .... |
| *Cyprinus carpio var* (communis) | 17·4–19·8 | .. | 0·16–0·18 | .. | .... |
| | 28·2–30·6 | .. | 0·25 | .. | .... |
| *Carrassius carassius* (Golden carp) | 18·7–19·6 | 5·8–6·1 | 0·12–0·17 | .. | .... |
| *Etroplus maculatus* | 31·4–31·6 | 2·2 | 0·64 | .. | Single fish. |
| | 31·4–31·6 | 2·2 | 0·24 | .. | Group effect. |
| *Tilapia mossambica* | 31·2 | 8·6 | 0·43 | 0·6 (7·67) | Adult. |
| | 31·4–31·6 | 4·3–4·9 | 0·75–0·71 | .. | Fingerling. |
| | 31·4 | .. | 0·96 | 0·85 (10·90) | Fry in groups. |
| *Cirrhina reba* | 26·6 | 10·9 | 0·35 | 0·74 (8·78) | .... |

* per cent saturation,

## Table No. II.

*Effect of volume of medium on oxygen consumption.*

("Oxygen dependent zone .")

| *Fish.* (1) | | *Volume of water litres.* (2) | *Oxygen consumption mg/g/hour.* (3) |
|---|---|---|---|
| *Cirrhina cirrhosa*— | I | 3·0 | 1·9 (per fish). |
| | | 2·0 | 1·795 (per fish). |
| | II | 2·75 | 0·482 |
| | | 1·75 | 0·410 |
| | III | 2·75 | 0·830 |
| | | 1·75 | 0·455 |
| *Mirror carp*— | I | 3·0 | 0·267 |
| | | 2·0 | 0·250 |
| | II | 3·0 | 0·493 |
| | | 2·0 | 0·377 |
| *Mirror carp*—cont. | III | 11·0 | 0·434 |
| | | 2·75 | 0·384 |
| | IV | 11·0 | 0·332 |
| | | 2·75 | 0·311 |
| | V | 11·0 | 0·604 |
| | | 1·0 | 0·556 |
| *Barbas carnaticus* | | 11·0 | 0·9107 |
| | | 5·0 | 0·2404 |
| *Labco fimbriatus* | | 3·0 | 0·639 |
| | | 2·0 | 0·373 |

### TABLE No. III.

*Effect of size on oxygen consumption.*

| *Fish.* | *Length cms.* | *Weight. gms.* | *Oxygen consumed mg/hr/g of body weight.* | *Temperature °C.* |
|---|---|---|---|---|
| *Cyprinus carpio var specularis* (Mirror carp) | .. | 48·92 | 0·254 | 30·6–30·8 |
| | .. | 18·40 | 0·324 | 30·6–30·8 |
| | .. | 3·70 | 0·604 | 30·6–30·8 |
| | .. | 14·00 | 0·267 | 27·2 |
| | .. | 16·00 | 0·250 | 27·2 |
| | .. | 6·1 | 0·434 | 27·4–27·6 |
| | .. | 11·0 | 0·384 | 27·4–27·6 |
| | .. | 13·9 | 0·311 | 27·4–27·6 |
| *Barbus carnaticus* | 6·5 | 4·48 | 0·482 | 31·4 |
| | 10·1 | .. | 0·470 | |
| | 11·8 | 15·80 | 0·269 | |
| | 12·5 | 16·64 | 0·240 | 30·4–30·8 |
| | 14·1 | .. | 0·182 | |
| *Carassius carassius* | 5·8 | 1·63 | 0·169 | 18·7 |
| | 6·1 | 1·92 | 0·156 | 18·7 |
| | 1·92 | .. | 0 250 | 20·2 (per fry) |
| | 2·00 | .. | 0·200 | 20·2 (per fry) |
| *Tilapia mossambica* | 8·6 | 16·8 | 0·427 | 31·2–31·6 |
| | 4·9 | 1·12 | 0·710 | 31·2–31·6 |
| | 4·3 | 0·84 | 0·749 | 31·2–31·6 |
| | Fry | 0·10 | 2·000 | 31·2–31·6 |
| *Cata catla* | 28·6 | 55·00 | 0·111 | 28·6 |
| | 14·2 | 30·00 | 0·193 | 28·6 |
| | 12·2 | 21·50 | 0·273 | 28·0 |
| *Labto fimbriaeus* | .. | 11·40 | 0·633 | .. |
| | .. | 18·65 | 0·448 | .. |
| | 2·5 | 0·68 | 0·804 | .. |
| | 4·0 | 1·60 | 0·787 | .. |

### TABLE No. IV.

*"Group effect" on oxygen consumption by fresh water fish.*

| *Fish.* (1) | *Number.* (2) | *Oxygen consumption mg/g/hr.* (3) |
|---|---|---|
| *Mirror carp*— | | |
| I | 1 | 0·493 |
| | 6 | 0·347 |
| II | 1 | 0·604 |
| | 4 | 0·324 |
| III | 2 | 0·344 |
| | 8 | 0·326 |
| IV | 2 | 0·575 |
| | 10 | 0·297 |
| *Barbus mahecola*— | | |
| .. | 2 | 0·434 |
| | 4 | 0·325 |
| | 6 | 0·267 |
| *Talapia mosambica* (fry) | 4 | 2·000 |
| | 34 | 0·955 |
| *Etroplus maculatus* (fry) | 3 | 0·637 |
| | 15 | 0·235 |
| *Golden carp* | 1 | 0·300 |
| | 3 | 0·266 |
| *Labeo fimbriatus* (fry) | 24 | 0·787 |
| | 17 | 0·900 |
| | 2 | 1·800 |

TABLE No. V.

*Effect of certain chemicals on oxygen consumption.*

| *Name of chemical.* | *Conc. mg./L.* | *Fish.* | *Oxygen consumed mg/g/hr.* | | *Remarks.* |
|---|---|---|---|---|---|
| | | | *Experimental.* | *Control (no chemical).* | |
| (1) | (2) | (3) | (4) | (5) | (6) |
| Thiourocil | 10 | *Mirror carp* | 0·240 | 0·267 | |
| | 10 | Do. | 1·420* | 3·856* | |
| | 10 | Do. | 1·900* | 3·120* | |
| | 10 | Do. | 0·355 | 0·493 | |
| | 10 | *Cirrhina cirrhosa* | 1·640* | 1·900* | |
| Urethane | 10 | Do. | 0·207 | 0·482 | |
| Verenal (Barbitone) | 20 | Do. | 0·131 | 0·390 | |
| | 20 | *Tilapia mossambica* | 0·635 | 0·749 | |
| | 20 | Do. | 0·710 | 0·954 | |
| | 20 | Do. | 0·599 | | |

* Per fish per hour.

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# ON THE FISH LANDINGS AND FISHERY TREND AT CAPE COMORIN

BY

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## Introduction

The fishery potentialities of the Arabian sea, the Indian Ocean and the Bay of Bengal are rich and the unique location of Cape Comorin at the Southern tip of the Indian sub-continent makes it an ideal place for exploiting these vast fishery resources. Geographically Cape Comorin is situated in Latitude 8°6′ N and Longitude 77°60′ E and the fishing village proper is situated on the eastern side of the promontory and extends over one mile along the coastline towards the north. The fish landing place behind the local Catholic Church is fairly protected from the fury of the waves by a group of rocks on the southern side and a rocky headland on the north. Being one of the important fishing centres of Madras State, a systematic collection of the daily statistics of the fish landings at Cape Comorin was made from the year 1957 onwards, as a routine item of work of the Marine Biological Station. The monthly landings and their species composition during the years 1957 and 1958 were already published by Ramanandham and Chacko (1962). The present paper details the fish landings of the place over a six-year period from 1958 to 1963, the present status of the fishing industry at Cape Comorin and the fishery trend in the area.

## Present status of Fishing Industry at Cape Comorin

There are 3,183 fishermen, women and children with 1,115 individuals actively engaged in fishing at Cape Comorin (Chacko and George, 1958). The boat catamarans ranging from 14 ft. to 23 ft. in length and made of 3 to 5 logs lashed together form the only indigenous fishing craft of this place and they total in number to about 500. Eight Pablo type mechanised boats supplied by the State Fisheries department are also operated here from 1959 onwards and they are being operated from Leepuram, a small bay about 2·8 meters north of Cape Comorin, with better anchoring facilities.

Both hook and line fishing and net fishing are carried out successfully throughout the year. The exploitation of the 'Wadge Bank' and "Padukattu Par" is solely through hooks and lines. The fishermen start early morning, purchase the bait on the way from the homeward-bound fishermen, go up to 10 to 12 miles from the shore and return with their catches in the afternoon. A significant portion of the total fish landings is caught through hook fishing. "Boat seines" (Thattumadi) are the most important and efficient of the indigenous tackles used here and are operated from five fathoms upwards right through the year for catching all shoaling fishes. About 250 boat seine nets are used in the village besides the usual type of gill nets like Vala Valai (about 50 Nos.), Katcha Valai and Nethili Valai (about 80 Nos.) and Chala Valai (about 50 Nos.) which are operated only seasonally when shoaling of the particular variety of fish occurs. In recent years Nylon nets have also come into use along with the mechanised boats. The nets are usually operated within a radius of five miles, the fishermen leaving the shore past midnight or early in the morning and landing the fish early in the morning and before noon. During the peak fishing season when shoaling of ribbon fish or white baits takes place in close inshore area, the same fishing unit may undertake two or three consecutive trips the same day.

The varieties of fish usually caught in the different types of nets are as follows :—

*Hooks and Lines.*

Serranus
Lethrinus

Lutjanus
Aprion
Sharks, Skates and Rays.
Caranx
Megalaspis
Chirocentrus
Arius
Cybium
Diagramma
Sciaena
Sphyraena
Thynnus
Belone
Elacate
Albula
Otolithus

*Boat Seines.*

Leiognathus
Caranx

Stromateus
Lactarius
Pellona

Arius
Dussumieria
Anchoviella
Trichiurus
Sciaena
Pristipoma
Sphyraena
Upeneoides
Mackerel
Mugil
Prawns

*Gill and Drift nets.*

Leiognathus
Sharks, Skates and Rays.
Sardinella
Caranx.
Megalaspis.

Stromateus.
Chorinemus.
Chirocentrus
Arius
Pellona
Cybium
Anchoviella
Diagramma
Sciaena
Pristipoma
Hilsa

Balistes are caught in Dip nets (Katcha bag).

The important fishing grounds usually exploited by the fishermen are locally known as 'Kothala Madai'. 'Koyilannai Par' 'Uyarathannai Par', 'Velikkannai Par', 'Valayal Par', Padukattu Par', and 'Sura Par' and their approximate location are shown in the map in Annexure I. Excepting the last 2 grounds, all the rest are situated very near to Cape Comorin. The 'Padukattu Par' is about 14 miles from Cape Comorin and the 'Sura Par' (Wadge Bank) is about 35 miles off Cape Comorin in a south-westerly direction and because of the long distance, they are exploited only seasonally in March and April when the sea is rather calm and the wind favourable. To reach the Wadge Bank, the fishermen take almost 12 hours when the wind is favourable and fish there for about 6 hours and the return journey takes another 12 to 16 hours. The catches are mainly rock-cods, perches and sea-breams and all are mostly in a putrid condition. They are cured with plenty of salt and sold in the internal markets. The fishery potentialities of the Wadge Bank have been described by John et. al. (1959). The fishermen of Kovalam, Muttom and the adjoining fishing villages also occasionally land their catches at Cape Comorin, because of the facilities for curing and transport of fish by lorry to interior places.

About 75 to 80 per cent of the fish landings at Cape Comorin are salt cured and only the remaining quantity is sold in fresh condition for local consumption and for supply to other centres like Nagercoil, Palayamcottai, Manalikara, Alur, Thackalay, Maikal Mandapam, Kulasekaram, Trivandrum and Chenganachery. The transport is mostly by bicycles and also by lorries when the distance is much. About 80 per cent of the salt-cured and dried fish is transported by lorry to Tuticorin for export to Ceylon. The rest is sent to internal markets like Madras, Koilpatti, Melapalayam, Valliyur, Tenkasi, Paramakudi, Madurai, Tiruchirappalli, Arkonam, Nazareth and Chenganachery.

## Materials and Methods

The catches of one-third of the total number of catamarans landing daily at the fishing village were examined in detail for their species composition and the quantity in kilogram of each species caught was noted. The total of the figures so obtained for all the catamarans examined was multiplied by 3 and recorded as the total daily landings of the place for each species. Statistics of daily landings was thus collected over a period of six years from 1958 to 1963.

## Discussion of results

The total monthly landings in each variety of fish every year during the six-year period 1958–63 are shown in Tables I to VI in annexure. The total annual landings in each veriety and the total average landings in each veriety during the period are shown in Table VII in annexure.

## Annual Landings

During the six-year period 1958–63, the total annual fish landings at Cape Comorin varied from a minimum of 1,130·347 tonnes in 1962 to a maximum of 2,601·519 tonnes in 1958, the average annual landings during the period being 1,772·821 tonnes. The fishery was above the average during the years 1958, 1959 and 1961 and during the other years it was below average. It will be seen from Table VII that the two major fisheries of the place are *Trichiurus* and *Anchoviella* and the failure of these two fisheries are responsible for the poor fishery in the years 1960, 1962 and 1963. The fishery in general showed a declining trend from 1958 to 1962 excepting for the year 1961 when there was a good fishery of *Anchoviella.*

As many as 35 varieties of fishes are landed in this place and their total annual landings during the six-year period are given in Table VII. In addition to these 35 varieties of fishes Lobsters (*Panulirus sp.*) are also being caught from November to April every year to cater the needs of the freezing factories at Cochin and for subsequent export of frozen lobster tails to U.S.A. and Canada. A preliminary report on the lobster fishery of Kanyakumari district coast has already been published by Ramanandham and Chacko (1962). Miyamato and Shariff (1961) studied the potentialities for lobsters on the south-west coast of India with special reference to the existing craft, fishing gear and method of fishing. Balasubramanian et. al. (1960& 1961) have also given an account of the rock lobster fishing experiments with bottom-set gill nets along the south-west coast of India. Size and sex composition of the catches of the lobsters along the Kanyakumari district coast in 1960–61 have been detailed by Radhakrishnan Nair (1963). The lobster fishery landings and trend during recent years in Kanyakumari district are being published separately (Srinivasan, R. and Ananthanarayanan, R. unpublished) and are therefore excluded from this publication. The names of the varieties in the order of importance according to the quantities landed during the study period are—*Trichiurus, Anchoviella, Lactarius, Caranx, Dussumieria, Serranus, Lethrinus, Arius, Sharks, skates and rays, Sardinella, Lutjanus Cybium, Leiognathus, Sciaena, Aprion, Stromateus, Sphyraena, Chorinemus, Decapterus, Megalaspis, Chirocentrus, Upeneoides, Balistes, Pristipoma, Diagramma Pellona, Mackerel, Drepane, Otolithus, Histiophorous, Albula, Hilsa, Elacate, Mullets,* and *Thynnus.* The first two varieties, namely *Trichiurus* and *Anchoviella* with average annual landings of 487·784 tonnes and 467·267 tonnes respectively form the 2 major fisheries of the place. *Lactarius* (average 217·370 tonnes), *Caranx* (Av. 156·734 tonnes) and *Dussumieria* (Av. 82·594 tonnes) also form important fishery. The annual fluctuations and proportions of the important species in the fish landings during the six-year period are shown in the histogram in Annexure II.

## Seasonal variations.

There is fishing right through the year, but the peak season is for five months only from June to October when more than 75 per cent of the total annual landings are caught as detailed in Table VIII in annexure.

It will be seen from this table that the maximum landings are between the months of July and October every year, the monthly maximum ranging from 235·981 tonnes in October 1962 to 893·077 tonnes in September 1961. The poorest fishing months are usually December, January and February, the total monthly catches during the off-season varying from 13·797 tonnes in January 1961 to 29·066 tonnes in January 1963. In 1959, the poorest fishing month was May when only 16·759 tonnes were landed. The important fishery during the peak season in all the years were *Trichiurus, Anchoviella, Lactarius, Caranx,* and *Dussumieria.* In 1963, there was a good fishery of *Arius* also during the peak season.

The maximum, minimum and average annual landings of each variety of fish during the six-year period, their percentage in the total annual landings and the months of their peak fishery are shown in Table IX in annexure in their decreasing order of importance.

It will be seen from this table that *Trichiurus* constitutes the most important fishery amounting to 27·5 per cent of the total landings and next comes *Anchoviella* accounting for 26·0 per cent of the total catches. *Lactarius* (12 per cent), *Caranx* (8·8 per cent), *Dussumieria* (4 per cent), *Serranus* (2·9 per cent), *Lethrinus* (2·1 per cent), *Arius* (2·0 per cent), Sharks, skates and rays (1·9 per cent), *Sardinella* (1·6 per cent), *Lutjanus* (1·2 per cent), *Cybium* (1·2 per cent), *Leiognathus* (1·1 per cent), and *Sciaena* (1 per cent) constitute the other important varieties landed in significant quantities. All other varieties caught put together amount to about 6 per cent only and are individually less than 1 per cent of the total landings. The first five varieties, namely, *Trichiurus*, *Anchoviella*, *Lactarius*, *Caranx* and *Dussumieria* account for 78·3 per cent of the total landings. All these five varieties are landed in large quantities during the peak fishery season between June and October, though they are also seen in small quantities in the off-season catches.

In 1958, *Anchoviella* (800·977 tonnes ), *Caranx* (397·647 tonnes), *Cybium* (36·233 tonnes), *Stromateus* (17·196) tonnes), *Decapterus* (21·898 tonnes), *Balistes* (16·363 tonnes) and *Histiophorus* (1·478 tonnes) were landed in maximum quantities during the six-year period. In 1959, *Sphyraena* (13·571 tonnes), *Chorinemus* (13·579 tonnes), and Mullets (0·555 tonnes) were landed in max. quantities. In 1960, *Dussumieria* (120·276 tonnes), *Sardinella* (49·729 tonnes), Megalaspis (10·122 tonnes), Mackerel (7·242 tonnes), *Otolithus* (2·346 tonnes), and *Elacate* (0·757 tonnes) were landed in max. quantities. In 1961, *Trichiurus* (755·387 tonnes), *Lactarius* (337·662 tonnes), Leiognathus (37·490 tonnes), *Sciaena* (30·236 tonnes), *Pristipoma* (9·084 tonnes), *Pellona* (3·098 tonnes) and *Drepane* (4·263 tonnes), were landed in max. quantities. In 1962, which was the poorest landing year in the six-year period, *Aprion* (44·658 tonnes) and *Diagramma* (5·759 tonnes) were landed in max. quantities. In 1963, *Serranus* (82·686 tonnes), *Lethrinus* (102·377 tonnes), Arius (61·923 tonnes), *Lutjanus* (52·319 tonnes), *Chirocentrus* (10·434 tonnes), *Upeneoides* (7·443 tonnes), *Albula* (1·407 tonnes), *Hilsa* (0·921 tonnes) and *Thynnus* (0·174 tonnes) were landed in max. quantities.

In 1958, the catches of *Lutjanus*, *Megalaspis*, *Upeneoides*, *Pellona*, Mackerel, *Albula*, *Hilsa*, *Elacate* and *Thynnus* were the lowest during the six-year period. In 1959, catches of *Sardinella*, *Decapterus*, *Chirocentrus*, *Pristipoma*, *Albula*, *Hilsa* and Tuna were the lowest during the period. In 1960, catches of *Serranus*, *Lethrinus*, *Leiognathus*, *Aprion*, *Sphyraena*, *Pristipoma*, *Diagramma*, *Hilsa* and Tuna were the lowest for the six-year period. In 1961, *Anchoviella*, *Dussumieria*, *Arius*, *Cybium*, Mullets and Tuna were the lowest for the six-year period. In 1962, *Trichiurus*, *Lactarius*, *Caranx* Sharks, skates and rays, *Stromateus*, *Chorinemus*, *Drepane*, *Otolithus*, and Mullets were the lowest for the six-year period. In 1963, *Sciaena*, *Decapterus*, *Balistes*, *Mackerel*, *Drepane*, *Otolithus* and *Histiophorus* recorded the lowest catches for the period of study. *Decapterus* was not landed during the year 1959, 1961 and 1963. *Pristipoma* was not seen in the catches in 1959 and 1960. Mackerel was not landed in 1958 and 1963. *Drepane* and *Otolithus* were not caught in 1962 and 1963. *Albula* was not landed in 1958 and 1959. Hilsa was not landed in 1958, 1959 and 1960. Mullets were not caught in 1961 and 1962 and Tuna was not caught till 1961.

## Fishery Calendar

Every year, the months of June to October form the peak fishing season, when the following varieties are landed in fairly good quantities—*Trichiurus*, *Anchoviella*, *Lactarius*, *Caranx*, *Dussumieria*, Sharks, skates and rays, *Sardinella*, *Stromateus*, *Spyraena*, *Decapterus* and *Drepane*. During the off-season the following varieties are landed—*Serranus*, *Lethrinus*, *Lutjanus*, *Arius*, *Cybium*, *Leiognathus*, *Sciaena*, *Aprion*, *Chorinemus*, *Megalaspis*, *Chirocentrus*, *Upeneoides*, *Balistes*, *Pristopoma*, *Pellona*, *Otolithus* and *Histiophorus*.

A fishery calendar for the Kanyakumari district coast was already prepared by Chacko and George (1958 loc. cited). A more exhaustive fishery calendar for Cape Comorin has been worked out based on the fisheries of the six-year period 1958–1963 and is shown in Table X in annexure. The names of fishes have been arranged in thislist in the order ofimportance according to the quantities landed during each month. It will be seen from this calendar that seer is landed in good quantities from November to February, the maximum being in the months of December and January. *Lethrinus*, *Serranus*, *Lutjanus*, and *Aprion* form the major fishery in the catches during the months from February to May. Arius is predominant in the catches in December and April. *Caranx* is landed right through the year, the maximum being during the months of May to October. *Sardinella* is available right through the year with 2 peaks, one in May and another in November. *Anchoviella* has season from June to November and *Trichiurus* from June to October. *Lactarius* is landed in good quantities from September to November and Rainbow-Sardines from June to September. Pomfrets and Sharks, rays and skates are landed right through the year.

## Relationship to Fishing Effort

The monthly averages and annual averages of the number of catamarans that went for fishing every day during the six-year period 1958–63 are shown in Table XI in annexure.

It will be seen from this table that only about 100 catamarans are engaged daily in fishing on the average during the off-season and the number of catamarans are nearly doubled during the peak fishing season from June to October every year. There has also been a steady decline in the number of catamarans year after year from 1958 to 1960 and in 1962 and the position has slightly improved in 1963. This closely follows the annual fishery trend also and during the year 1961, when there was a good fishery of Anchoviella, the number of catamarans had actually increased. Though there are as many as 500 catamarans in the village all of them do not go for fishing simultaneously and only a maximum of 300 catamarans/day on the average were found to go for fishing even during the peak fishing season. The general tendency had been for more number of catamarans to go for fishing whenever the catches had been good and this would suggest an apparent direct proportionate relationship between the number of the catamarans and the landings. But a more close scrutiny of the monthly variations in the catching efforts and the landings revealed that landings were not directly proportionate to the number of catamarans engaged in fishing.

**Fishery Trend**

The total annual landings decreased generally from the year 1958 to 1960, increased in 1961, but again decreased in 1962 to the lowest figure for the six-year period and again showed an improvement during the year 1963. The same trend is reflected in the *Trichiurus* fishery which is the most important fishery of Cape Comorin. From an annual landings of 724·100 tonnes in 1958, the *Trichiurus* catches steadily decreased to about 233·249 tonnes in 1960, recorded the maximum catches of 755·387 tonnes in 1961, and the minimum of 233·119 tonnes in 1962 and the catches improved in 1963. The second important fishery of the place, namely, *Anchoviella* also followed the same trend, commencing from a maximum of 800·977 tonnes in 1958, gradually declining year after year and touching the minimum catches of 306·902 tonnes in 1961. There has been no further decline of the white bait fishery after 1961 and the annual landings remain more or less steady at the figure of about 350 tonnes. The *Lactarius* fishery, which is 3rd in importance was more or less steady during the entire period of study with an average annual landings of 217·370 tonnes and recorded a maximum of 337·370 tonnes in 1961 followed by a minimum of 104·064 tonnes only in 1962. *Caranx* has declined considerably during the years 1962 and 1963, when compared with the previous years. *Dussumieria* recorded a steep-fall in 1961 and is since showing signs of gradual revival. The landings of *Serranus*, *Lethrinus*, *Lutjanus*, *Arius* and *Cybium* are found on the increase during the recent year . *Sardinella* is on the decline.

All the fishery trend referred above may be due to natural causes like the annual fluctuations in the fishery only, since there has been not much appreciable change in the catching effort year after year. Lobsters (*Panulirus sp.*) have gained increasing importance as a commercial fishery during the study period, because of their demand in the freezing plants at Cochin for export to U.S.A. and Canada. The attractive prices offered by these companies for the lobsters, have tended to increase lobster-fishing at Cape Comorin as in other places in Kanyakumari district during the months of November to April every year. The lobster fishery trend in Kanyakumari district is being discussed in detail and published separately (Srinivasan, R and Anantanarayanan, R. un-published.).

The months during which the important fisheries of Cape Comorin had their peak seasons during the different years of the six-year period are shown in Table XII in annexure.

From this table it will be seen that the peak seasons for the two important and major fisheries of the place, namely *Trichiurus* and *Anchoviella* continue to be the months from June to October, though in recent years the trend has been towards later commencing of the fishery in July or even in August. *Lactarius* continues to be caught in good quantities in September and October. Rainbow-Sardines though normally expected in the months of June to October every year seem to have shorter duration of fishery for two months only in June and July in recent years. *Serranus*, *Lethrinus* and *Lutjanus* have a trend towards extended and bigger fishery year after year. The perches are now caught from December to July and in larger amounts. *Arius* which seemed to have two peak seasons one in January-February and another in July-October at the beginning of the study period, had only one fishery from June to September in 1962 and from June to December in 1963. *Sardinella* continues to have two seasons from March to May and October to December, though in 1963, the fishery in November-December only was significant. *Cybium* continues to be a good fishery from October to February every year.

## *Summary.*

The present status of the fishing industry at Cape Comorin is briefly described. The total monthly and annual landings of the 35 different varieties of fishes caught at Cape Comorin during the six-year period 1958 to 1963 are detailed and the annual and seasonal variations in the landings and the fishery trend in the area are discussed. *Trichiurus* and *Anchoviella* with average annual landings of 487·784 tonnes and 467·267 tonnes respectively from the two major fisheries of the place and account for 27·5 per cent and 26 per cent respectively of the total catches. *Lactarius* (average annual landings 217·370 tonnes and 12 per cent of the total catches), *Caranx* (av. annual landings 156·734 tonnes and 8·8 per cent of the total catches) and *Dussumieria* (av. annual landings 82·59 tonnes and 4 per cent of the total catches), *Serranus* (av. 50·805 tonnes and 2·9 per cent of the total catches), *Lethrinus* (av. 35·427 tonnes and 2·0 per cent of total catches). Sharks, skates and rays (av. 33·847 tonnes and 1·9 per cent of total catches), *Sardinella* (av. 27·899 tonnes and 1·6 per cent of total catches), *Lutjanus* (av. 22·009 tonnes and 1·2 per cent of total catches) and Seer (av. 21·939 tonnes and 1·2 per cent of total catches) constitute the other important varieties landed at Cape Comorin in significant quantities. Though fishing is done at Cape Comorin right through the year, the peak fishing season is for five months only from June to October every year when more than 75 per cent of the total annual landings are caught. *Trichiurus*, *Anchoviella*, *Lactarius*, *Caranx*, *Dussumieria*, Sharks, Skates and rays, *Sardinella*, *Stromateus* and *Sphyraena* are the predominent catches during the peak season. During the off-season, *Serranus*, *Lethrinus*, *Lutjanus*, *Arius*, *Cybium*, *Sciaena*, *Aprion* and *Chorinemus* are caught in fairly good quantities. Based on the fish landings of the different varieties during the six-year period, an exaustive fishery calendar for Cape Comorin has been worked out.

The fishery in general showed a declining trend from the year 1958 to 1962 excepting for 1961 when there was a good fishery of white baits and signs of gradual recovery were noted during the year 1963. The same trend was noticed in the catches of *Trichiurus* and *Anchoviella*, the two major fisheries of the place. *Lactarius* was found to be steady, while *Caranx* and *Sardinella* had declined considerably during 1962 and 1963. Rainbow sardines recorded a steep fall in 1961 but has since shown signs of gradual revival. Perches, Arius and Seer landings show an increasing trend during recent years. The *Anchoviella*

and *Trichiurus* fishery trend to commence late in July or August only during recent years instead of in June. Rainbow sardines trend to have a fishery of shorter duration while the perches have a trend towards extended and bigger fishery during recent years. Since there has not been appreciable change in the catching effort at Cape Comorin during the six-year period, the fishery trend in the area may be mainly due to natural causes only.

## *Acknowledgments.*

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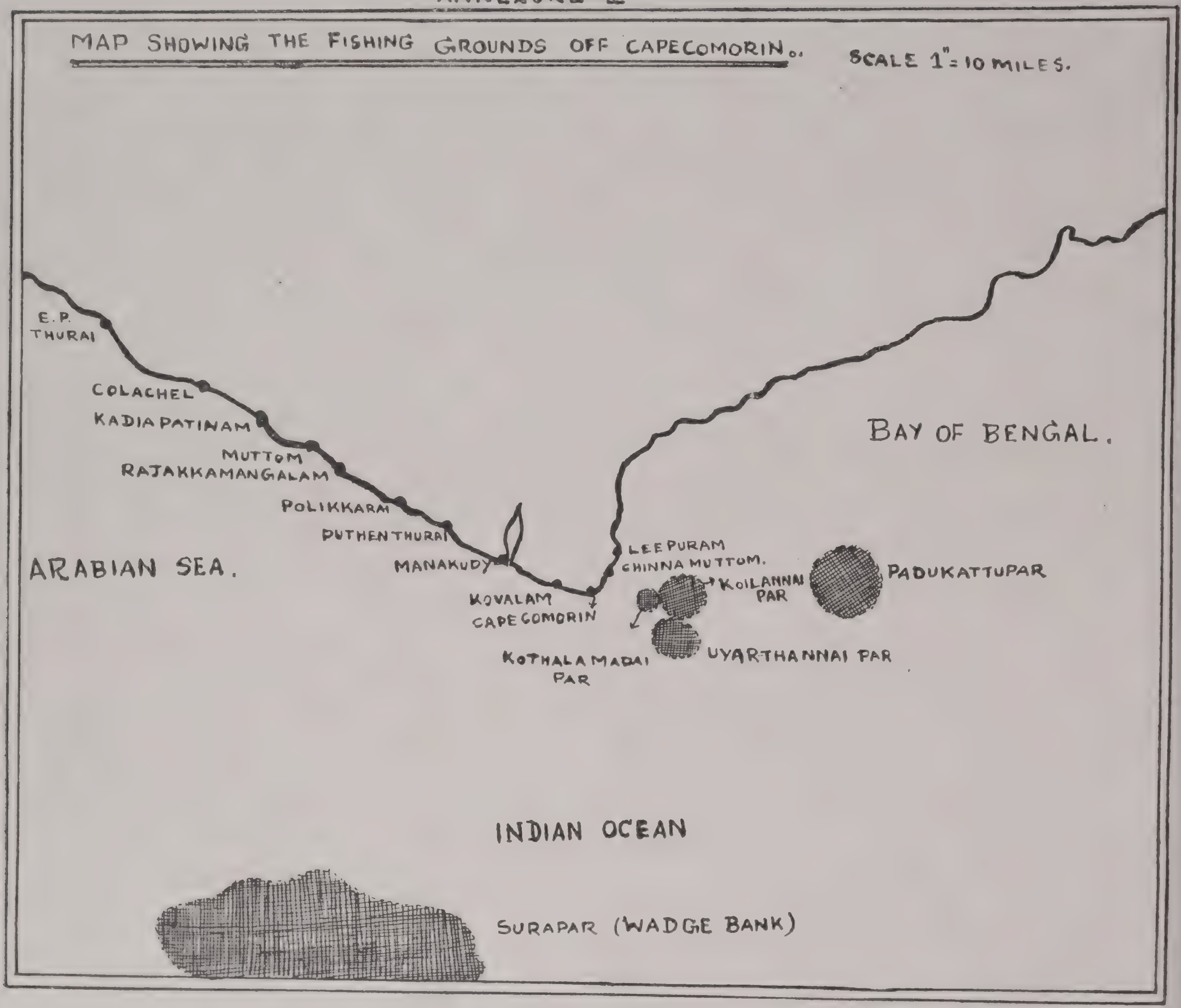
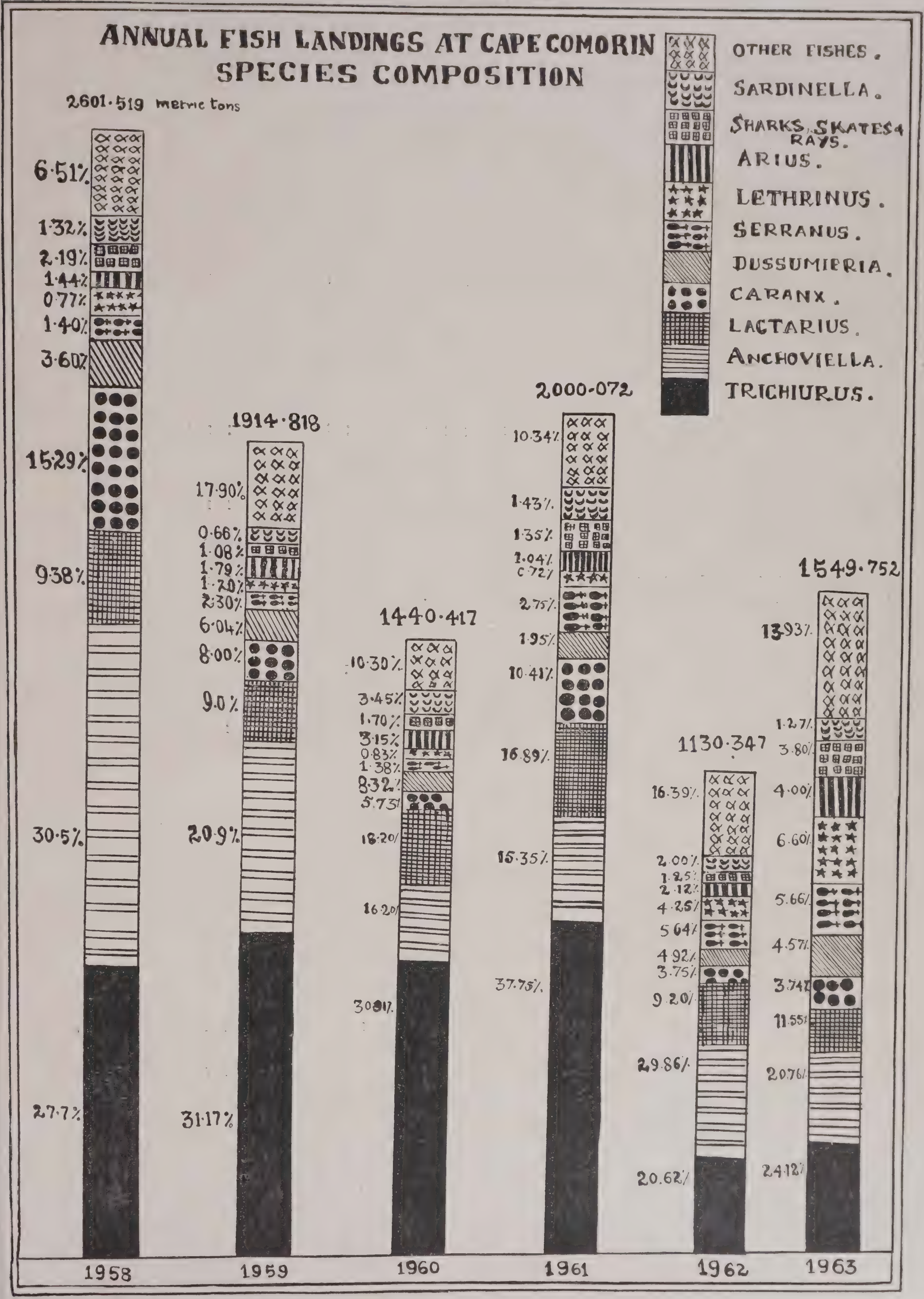
ANNEXURE- I


MAP SHOWING THE FISHING GROUNDS OFF CAPECOMORIN.
SCALE 1" = 10 MILES.
E.P. THURAI
COLACHEL
KADIAPATINAM
MUTTOM
RAJAKKAMANGALAM
POLIKKARAI
PUTHENTHURAI
MANAKUDY
ARABIAN SEA.
KOVALAM
CAPECOMORIN
LEEPURAM
CHINNA MUTTOM.
KOILANNAI PAR
PADUKATTUPAR
KOTHALAMADAI PAR
UYARTHANNAI PAR
BAY OF BENGAL.
INDIAN OCEAN
SURAPAR (WADGE BANK)

## ANNEXURE-II



ANNUAL FISH LANDINGS AT CAPE COMORIN
SPECIES COMPOSITION

TABLE I.

*Showing the total monthly landings in each variety of fish during the year 1958 in tonnes at Cape Comorin.*

| *Serial number and varieties.* | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* | *Total.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 1 Anchoviella .. .. | 2·591 | 1·182 | 0·068 | 1·182 | 0·045 | 118·182 | 127·727 | 228·182 | 190·909 | 122·727 | 7·273 | 0·909 | 800·977 |
| 2 Trichiurus .. .. | 0·591 | 0·773 | 0·136 | 0·034 | 0·341 | 113·636 | 356·816 | 131·818 | 100·000 | 10·455 | 9·091 | 0·409 | 724·100 |
| 3 Caranx .. .. | 5·227 | 1·818 | 0·773 | 0·955 | 29·545 | 52·955 | 27·955 | 227·273 | 20·939 | 24·091 | 4·308 | 1·818 | 397·647 |
| 4 Lactarius .. .. | 1·636 | 0·727 | 0·432 | 0·091 | 2·318 | 0·045 | .. | 1·818 | 209·091 | 25·909 | 1·364 | 0·682 | 244·113 |
| 5 Dussumieria .. .. | 0·295 | 0·045 | .. | .. | .. | 0·682 | 80·000 | .. | 11·273 | 1·409 | 0·682 | 0·136 | 94·522 |
| 6 Sharks, skates and rays. | 5·568 | 1·705 | 1·314 | 1·314 | 1·705 | 0·955 | 3·455 | 12·727 | 22·727 | 1·932 | 2·545 | 1·136 | 57·083 |
| 7 Serranus .. .. | 3·068 | 0·955 | 3·864 | 7·159 | 4·318 | 14·091 | 1·727 | 2·273 | 0·273 | 0·136 | 0·227 | 0·080 | 38·171 |
| 8 Cybium .. .. | 6·727 | 8·182 | 0·386 | 0·205 | 0·114 | .. | .. | 0·164 | 1·364 | 4·091 | 7·273 | 7·727 | 36·233 |
| 9 Sardinella .. | .. | .. | 5·795 | 7·091 | 2·955 | .. | 0·455 | 16·364 | .. | 1·682 | 0·136 | .. | 34·478 |
| 10 Arius .. .. .. | 2·682 | 3·523 | 1·114 | 0·091 | 0·136 | 0·795 | 4·227 | 5·273 | 0·864 | 5·909 | 1·591 | 0·909 | 27·114 |
| 11 Decapterus .. .. | .. | .. | .. | .. | .. | .. | .. | .. | 21·898 | .. | .. | .. | 21·898 |
| 12 Lethrinus .. .. | 0·614 | 5·455 | 6·591 | 1·591 | 1·136 | 0·682 | 0·273 | 3·955 | 0·114 | 0·032 | 0·136 | 0·080 | 20·659 |
| 13 Stromateus .. .. | 1·114 | 1·227 | 0·091 | 0·205 | 0·091 | 1·136 | 0·250 | 6·818 | 3·727 | 0·364 | 1·818 | 0·355 | 17·196 |
| 14 Sciaena .. .. | 2·636 | 0·341 | 0·914 | 0·273 | 0·795 | 0·159 | 0·227 | 1·455 | 0·136 | 1·409 | 0·682 | 4·091 | 13·118 |
| 15 Sphyraena .. .. | 0·386 | 0·773 | 0·080 | 0·091 | 0·136 | 0·091 | 0·102 | .. | 7·273 | 1·591 | 0·909 | 0·682 | 12·114 |
| 16 Leiognathus .. .. | 4·318 | 3·977 | 0·318 | 0·045 | 0·045 | 0·045 | 0·182 | .. | .. | 0·318 | 0·682 | 1·818 | 11·748 |
| 17 Balistes .. .. | .. | 3·636 | 4·727 | 2·000 | .. | .. | .. | .. | .. | .. | .. | .. | 10·363 |
| 18 Chorinemus .. .. | 1·591 | 1·227 | 1·091 | 2·955 | 2·045 | 0·091 | 0·091 | .. | .. | 0·068 | 0·114 | 0·114 | 9·307 |
| 19 Aprion .. .. | .. | .. | 2·273 | 5·045 | 1·705 | .. | .. | .. | .. | .. | .. | .. | 9·023 |
| 20 Lutjanus .. .. | 0·114 | 0·398 | 0·500 | 1·659 | 0·682 | 0·159 | .. | .. | .. | .. | .. | .. | 3·512 |
| 21 Prisptipoma .. | 0·795 | 1·864 | 0·459 | 0·068 | 0·080 | .. | .. | .. | .. | .. | .. | .. | 3·266 |
| 22 Drepane .. .. | .. | .. | .. | .. | 0·500 | 0·909 | 0·261 | 0·773 | .. | .. | 0·318 | .. | 2·761 |
| 23 Chirocentrus .. | 0·500 | 0·568 | 0·125 | .. | .. | .. | 0·023 | .. | 0·549 | .. | 0·727 | 0·077 | 2·569 |
| 24 Megalaspis .. .. | 0·795 | 0·455 | 0·549 | 0·227 | .. | .. | .. | .. | .. | .. | 0·182 | 0·455 | 2·663 |
| 25 Upeneoides .. .. | 0·182 | 0·364 | 0·614 | .. | .. | .. | 0·080 | .. | .. | 0·291 | 0·818 | 0·068 | 2·417 |
| 26 Histiophorus.. .. | 0·091 | .. | .. | 0·023 | .. | .. | .. | .. | .. | .. | 0·909 | 0·455 | 1·478 |
| 27 Otolithus .. .. | 0·227 | 0·318 | 0·341 | 0·034 | 0·045 | .. | 0·182 | .. | .. | 0·114 | .. | 0·045 | 1·306 |
| 28 Diagramma .. .. | .. | .. | 0·159 | 0·273 | 0·159 | 0·182 | 0·227 | 0·036 | .. | 0·023 | 0·023 | 0·023 | 1·105 |
| 29 Pellona .. .. | .. | 0·125 | 0·068 | .. | 0·080 | .. | .. | .. | .. | .. | .. | .. | 0·273 |
| 30 Mugil .. .. | .. | .. | .. | 0·250 | .. | .. | .. | .. | .. | .. | .. | .. | 0·250 |
| 31 Elacate .. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·055 | .. | 0·055 |
| Total weight .. | 41·748 | 39·638 | 32·802 | 32·861 | 48·976 | 304·795 | 604·180 | 438·929 | 591·107 | 202·551 | 41·863 | 22·069 | 2,601·519 |

### TABLE II.

*Showing the total monthly landings in each variety of fish during the year 1959 in tonnes at Cape Comorin.*

| *Serial number and varieties.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) | *Total.* (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Trichiurus | 0·114 | .. | .. | .. | 0·227 | 1·591 | 0·545 | 40·909 | 490·909 | 70·727 | 2·727 | 0·068 | 607·090 |
| 2 Lactarius | 0·549 | 0·091 | 0·182 | 0·227 | 0·114 | 3·636 | 0·909 | 0·909 | 30·909 | 127·273 | 11·364 | 0·818 | 176·981 |
| 3 Leiognathus | 3·864 | 7·955 | 1·068 | 0·227 | 0·136 | 0·227 | 0·318 | 0·114 | 0·682 | 0·273 | 2·727 | 5·227 | 22·818 |
| 4 Caranx | 2·159 | 4·545 | 1·636 | 1·136 | 2·045 | 35·227 | 5·000 | 10·000 | 56·818 | 25·455 | 5·455 | 2·045 | 151·521 |
| 5 Dussumieria | 0·045 | 0·091 | 0·159 | 0·909 | 0·114 | 14·545 | 40·227 | 27·273 | 17·045 | 9·545 | 1·818 | 4·091 | 115·862 |
| 6 Anchoviella | 0·409 |  | .. | .. | 0·549 | 1·364 | 37·727 | 159·091 | 177·273 | 172·727 | 8·182 | 3·864 | 561·186 |
| 7 Serranus | 0·114 | 3·977 | 18·864 | 10·455 | 0·682 | 1·250 | 5·000 | 2·273 | 1·364 | 1·159 | 0·045 | .. | 45·183 |
| 8 Arius | 5·909 | 0·549 | 0·136 | 0·682 | 0·455 | 0·227 | 2·273 | .. | 15·000 | 0·091 | 7·273 | 1·818 | 34·463 |
| 9 Cybium | 7·955 | 8·864 | 2·045 | 0·182 | 0·682 | 0·205 | 0·182 | 0·136 | 0·455 | 2·727 | 5·000 | 2·273 | 30·706 |
| 10 Lutjanus | 0·045 | 0·136 | 0·364 | 4·545 | 0·519 | 0·091 | 0·795 | 0·023 | 0·023 | .. | .. | 0·091 | 6·632 |
| 11 Lethrinus | 0·136 | 3·068 | 5·227 | 7·727 | 1·705 | 0·682 | 2·045 | 1·136 | 0·500 | 0·205 | 0·500 | 0·682 | 23·613 |
| 12 Sharks, skates and rays. | 2·727 | 1·000 | 1·136 | 1·591 | 1·136 | 0·591 | 1·250 | 1·364 | 2·045 | 3.727 | 1·909 | 2·364 | 20·840 |
| 13 Aprion | .. | 0·909 | 12·955 | 5·455 | 0·045 | .. | .. | .. | .. | .. | .. | .. | 19·364 |
| 14 Sciaena | 0·636 | 0·523 | 0·295 | 0·549 | 0·636 | 0·682 | 0·682 | 0·795 | 2·500 | 2·955 | 2·273 | 4·091 | 16·617 |
| 15 Chorinemus | 1·182 | 1·705 | 2·636 | 1.591 | 3·068 | 0·045 | 0·091 | 0·034 | .. | .. | 0·500 | 2·727 | 13·579 |
| 16 Sardinella | .. | .. | 0·659 | 4·091 | 3·864 | 0·045 | 0·159 | .. | 0·273 | 1·136 | 1·364 | 1·182 | 12·773 |
| 17 Stromateus | 2·023 | 4·091 | 0·432 | 0·159 | 0·136 | 0·795 | 0·409 | 0·500 | 1·136 | 0·549 | 0·182 | 0·549 | 10·961 |
| 18 Megalaspis, sp. | 0·136 | 0·636 | 0·227 | 0·114 | .. | .. | .. | 0·409 | .. | .. | 2·955 | 3·409 | 7·886 |
| 19 Sphyraena | 0·591 | 0·318 | 1·159 | 0·409 | 0·273 | 1·364 | 0·386 | 0·455 | 1·591 | 6·818 | 0·023 | 0·364 | 13·751 |
| 20 Balistes | .. | 2·955 | 2·432 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 5·387 |
| 21 Upeneoides | .. | 0·341 | 0·091 | 0·114 | .. | .. | .. | .. | 0·549 | 0·955 | 2·955 | .. | 5·005 |
| 22 Diagramma | 0·045 | 0·409 | 0·273 | 0·386 | 0·136 | 0·455 | 1·318 | 0·273 | 0·136 | .. | 0·023 | .. | 3·454 |
| 23 Drepane | 0·409 | 0·068 | .. | .. | 0·023 | .. | .. | .. | 1·364 | .. | .. | 0·182 | 2·046 |
| 24 Chirocentrus | 0·549 | 0·318 | 0·114 | .. | 0·068 | 0·023 | 0·068 | 0·068 | 0·409 | 0·045 | .. | 0·182 | 1·844 |
| 25 Otolithus | .. | 0·023 | .. | 0·068 | .. | .. | .. | .. | .. | 1·318 | 0·068 | .. | 1.477 |
| 26 Pellona | .. | .. | .. | .. | 0·114 | .. | .. | .. | .. | .. | .. | 1·364 | 1·478 |
| 27 Mackerel | .. | .. | .. | .. | .. | .. | .. | 0·682 | .. | .. | 0·091 | .. | 0·773 |
| 28 Histiophorus | 0·227 | 0·170 | 0·091 | .. | .. | .. | .. | .. | .. | 0·034 | 0·227 | .. | 0·749 |
| 29 Mugil | .. | 0·023 | .. | .. | 0·032 | .. | .. | .. | .. | .. | 0·500 | .. | 0·555 |
| 30 Elacate | 0·023 | 0·114 | .. | .. | .. | .. | .. | 0·041 | 0·023 | .. | 0·009 | 0·014 | 0·224 |
| **Total weight** | 29·847 | 42·929 | 52·181 | 40·617 | 16·759 | 63·045 | 99·384 | 246·485 | 801·004 | 426·992 | 58·170 | 37·405 | 1,914·818 |

# TABLE III.

*Showing the total monthly landings in each variety of fish during the year 1960 in tonnes at Cape Comorin.*

| *Serial number and varieties.* | *January.* | *February.* | *March.* | *April.* | *May.* | *June.* | *July.* | *August.* | *September.* | *October.* | *November.* | *December.* | *Total.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 1 Anchoviella .. .. | 0·341 | 0·273 | 0·091 | 0·409 | 0·686 | 56·336 | 52·773 | 78·026 | 104·805 | 142·616 | 3·850 | 5·002 | 445·208 |
| 2 Lactarius .. .. | 0·455 | 0·136 | 0·091 | 0·909 | 0·182 | 0·090 | 0·470 | 0·869 | 21·145 | 237·481 | 0·072 | 0·422 | 262·322 |
| 3 Trichiurus .. .. | 0·068 | 0·136 | 0·091 | 0·091 | 0·068 | .. | 32·055 | 137·502 | 2·085 | 60·757 | 0·301 | 0·093 | 233·247 |
| 4 Dussumieria .. .. | 0·159 | 0·045 | 1·132 | 2·727 | 1·132 | 29·561 | 29·729 | 43·466 | .. | 3·875 | 2·530 | 5·920 | 120·276 |
| 5 Caranx .. .. | 0·409 | 0·686 | 1·591 | 1·818 | 10·909 | 9·916 | 19·111 | 7·088 | 25·440 | 2·481 | 1·375 | 1·678 | 82·502 |
| 6 Sardinella .. .. | .. | .. | 3·182 | 9·091 | 13·864 | .. | 0·120 | .. | 0·043 | 9·859 | 12·157 | 0·413 | 49·729 |
| 7 Arius .. .. | 3·636 | 1·591 | 0·686 | 0·636 | 0·364 | 1·714 | 10·677 | 0·576 | 21·101 | 1·527 | 0·499 | 2·352 | 45·359 |
| 8 Sharks, skates and rays. | 2·386 | 1·818 | 2·273 | 1·182 | 0·273 | 0·629 | 7·872 | 1·537 | 1·273 | 2·336 | 1·792 | 1·173 | 24·544 |
| 9 Sciæna .. .. | 3·295 | 0·686 | 0·341 | 0·727 | 0·182 | 0·164 | 0·283 | 0·224 | 2·472 | 6·436 | 2·826 | 6·239 | 23·875 |
| 10 Decapterus .. .. | .. | .. | .. | .. | .. | .. | .. | 20·008 | .. | .. | .. | .. | 20·008 |
| 11 Cybium .. .. | 0·386 | 1·227 | 0·795 | 0·432 | 0·068 | .. | .. | 0·446 | 1·099 | 6·624 | 5·455 | 2·774 | 19·306 |
| 12 Sorranus .. .. | 0·568 | 0·341 | 7·955 | 6·591 | 0·636 | 1·294 | 1·006 | 0·085 | 1·429 | 0·025 | .. | .. | 19·930 |
| 13 Lothrinus .. .. | 1·250 | 1·132 | 5·909 | 1·818 | 0·500 | 0·184 | 0·494 | 0·072 | 0·057 | .. | 0·123 | 0·461 | 12·000 |
| 14 Chorinemus .. .. | 2·273 | 2·500 | 3·409 | 2·203 | 0·636 | .. | .. | .. | .. | 0·002 | 0·048 | 0·050 | 11·121 |
| 15 Stromateus .. .. | 0·227 | 0·549 | 0·182 | 0·182 | 0·136 | 0·622 | 2·603 | 0·135 | 1·177 | 1·753 | 4·185 | 0·665 | 12·416 |
| 16 Megalaspis .. .. | 1·636 | 0·909 | 0·818 | 0·455 | 0·045 | .. | 0·029 | .. | .. | 0·442 | 5·060 | 0·728 | 10·122 |
| 17 Mackerel .. .. | .. | .. | .. | .. | .. | .. | 0·316 | 6·237 | .. | .. | 0·689 | .. | 7·242 |
| 18 Leiognathus .. | 0·686 | 0·909 | 0·686 | 0·909 | 0·227 | 0·735 | 0·225 | 0·065 | 0·093 | 0·406 | 0·574 | 1·423 | 6·938 |
| 19 Lutjanus .. .. | .. | 0·295 | 3·182 | 2·364 | 0·091 | 0·061 | 0·236 | 0·338 | .. | 0·016 | .. | .. | 6·583 |
| 20 Aprion .. .. | .. | .. | 2·955 | 2·955 | .. | .. | .. | .. | .. | .. | .. | .. | 5·910 |
| 21 Chirocentrus .. .. | 0·614 | 0·091 | 0·227 | 0·091 | .. | .. | .. | .. | 0·481 | 1·425 | 0·161 | 0·022 | 3·118 |
| 22 Sphyræna .. .. | 0·068 | 0·027 | 0·182 | 0·159 | 0·023 | 0·153 | 0·342 | 0·640 | 1·237 | 1·125 | 0·295 | 0·132 | 4·383 |
| 23 Upeneoides .. .. | .. | .. | .. | 0·295 | .. | .. | .. | .. | 0·329 | 2·55 | 0·222 | 0·064 | 3·465 |
| 24 Otolithus .. .. | 0·273 | 0·455 | 0·273 | 0·591 | 0·091 | 0·007 | 0·086 | 0·020 | .. | 0·550 | .. | .. | 2·346 |
| 25 Balistes .. .. | .. | 1·000 | 0·909 | 0·205 | .. | .. | .. | .. | .. | .. | .. | .. | 2·114 |
| 26 Pellona .. .. | 6·795 | 0·227 | 0·091 | 0·182 | .. | 0·334 | 0·080 | .. | .. | .. | .. | .. | 1·709 |
| 27 Histiophorus .. | 0·091 | 0·091 | .. | .. | .. | .. | .. | .. | .. | 0·164 | 0·675 | 0·227 | 1·248 |
| 28 Drepane .. .. | 0·068 | .. | .. | .. | .. | .. | 0·581 | .. | .. | .. | 0·449 | .. | 1·098 |
| 29 Diagramma .. .. | .. | 0·136 | 0·227 | 0·045 | .. | 0·86 | 0·342 | 0·121 | .. | .. | .. | .. | 0·951 |
| 30 Albula .. .. | .. | .. | .. | .. | .. | 0·139 | 0·244 | 0·387 | .. | .. | .. | .. | 0·770 |
| 31 Elacate .. .. | .. | 0·068 | .. | 0·045 | .. | 0·102 | 0·067 | 0·280 | .. | 0·195 | .. | .. | 0·757 |
| 32 Mugil .. .. | .. | 0·027 | 0·068 | .. | 0·023 | .. | .. | .. | .. | .. | .. | .. | 0·118 |
| Total weight .. | 19·684 | 15·355 | 37·346 | 37·112 | 30·136 | 102·121 | 159·441 | 298·122 | 185·272 | 482·652 | 43·338 | 29·838 | 1,440·417 |

## TABLE IV.

*Showing the total monthly landings in each variety of fish during the year* 1961 *in tonnes at Cape Comorin.*

| *Serial number and varieties.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) | *Total.* (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Trichiurus .. .. | .. | .. | 0·543 | 0·309 | 0·932 | 6·162 | 40·979 | 224·643 | 441·644 | 32·208 | 2·237 | 5·730 | 755·387 |
| 2 Lactarius .. .. | 0·466 | 0·283 | 1·332 | 16·785 | 9·906 | .. | .. | 0·264 | 245·106 | 50·933 | 1·999 | 0·588 | 337·662 |
| 3 Anchoviella .. .. | 0·115 | .. | .. | 2·427 | 1·249 | 14·619 | 25·815 | 75·357 | 126·321 | 56·439 | 4·556 | .. | 306·902 |
| 4 Caranx .. .. | 0·720 | 1·055 | 2·010 | 3·726 | 9·761 | 14·288 | 3·759 | 107·331 | 52·576 | 9·522 | 1·591 | 1·869 | 208·208 |
| 5 Lutjanus .. .. | 0·625 | 4·254 | 27·057 | 8·517 | 0·585 | 0·252 | 0·477 | 0·489 | 0·231 | 0·129 | 0·353 | 0·468 | 43·437 |
| 6 Serranus .. .. | 0·257 | 10·236 | 16·020 | 10·260 | 6·720 | 4·216 | 4·248 | 0·258 | 0·078 | .. | 0·612 | 0·105 | 55·010 |
| 7 Dussumieria .. .. | 0·286 | 0·144 | 0·843 | 3·033 | 0·471 | 28·872 | 0·048 | .. | 2·919 | 1·971 | 0·258 | 0·030 | 38·875 |
| 8 Leiognathus .. | 1·220 | 3·910 | 1·284 | 19·701 | 2·262 | .. | .. | 1·050 | 2·613 | 0·696 | 1·709 | 3·045 | 37·490 |
| 9 Sciæna .. .. | 0·343 | 1·164 | 2·127 | 3·279 | 0·555 | 1·149 | 1·077 | 2·667 | 10·179 | 2·448 | 2·125 | 3·123 | 30·236 |
| 10 Sardinella .. .. | 0·080 | 1·278 | 0·081 | 7·239 | 16·565 | 0·375 | .. | .. | 0·189 | 2·727 | .. | .. | 28·534 |
| 11 Sharks, skates and rays. | 0·929 | 1·188 | 3·825 | 2·709 | 1·044 | 3·225 | 3·994 | 3·555 | 3·048 | 1·800 | 1·458 | 0·864 | 27·099 |
| 12 Arius .. .. | 1·944 | 1·296 | 6·515 | 1·593 | 2·516 | 2·163 | 2·163 | 1·005 | .. | 0·144 | 2·007 | 1·305 | 20·651 |
| 13 **Lethrinus** .. .. | 0·870 | **5·475** | 1·245 | 1·401 | 1·227 | 1·500 | 0·796 | 0·501 | 0·132 | 0·256 | 0·598 | 0·282 | 14·283 |
| 14 Stromateus .. .. | 0·035 | .. | 0·729 | 0·612 | 0·081 | 0·111 | 5·100 | 4·758 | .. | 0·723 | 0·438 | 0·078 | 12·661 |
| 15 Sphyræna .. .. | 0·240 | 1·106 | 0·054 | 2·325 | 0·156 | 0·231 | 0·755 | 0·300 | 2·097 | 4·780 | 0·329 | 0·087 | 12·460 |
| 16 Cybium .. .. | 1·235 | 4·233 | .. | .. | .. | .. | .. | .. | 1·158 | 0·394 | 0·630 | 4·170 | 11·820 |
| 17 Aprion .. .. | .. | 0·717 | 5·235 | 3·378 | .. | .. | .. | .. | .. | .. | .. | .. | 9·330 |
| 18 Pristipoma .. .. | .. | 0·564 | 5·103 | 1·296 | 0·507 | .. | .. | .. | 0·912 | .. | 0·081 | 0·621 | 9·084 |
| 19 Chorinemus .. .. | 1·259 | 0·849 | 1·074 | 1·344 | 0·822 | 0·258 | 0·060 | 0·105 | .. | 0·021 | 0·084 | 1·104 | 6·980 |
| 20 Chirocentrus .. .. | 0·245 | 0·900 | 0·126 | 0·177 | 0·015 | .. | .. | 1·755 | 0·894 | 2·201 | 0·131 | 0·258 | 6·652 |
| 21 Megalaspis .. .. | 0·927 | 0·195 | 0·687 | 0·288 | .. | 0·048 | .. | .. | .. | 1·270 | 1·045 | 1·758 | 6·218 |
| 22 Upeneoides .. .. | .. | 0·267 | 1·443 | 0·762 | .. | .. | .. | .. | 1·890 | 1·818 | 0·321 | 0·095 | 6·596 |
| 23 Drepane .. .. | .. | .. | .. | .. | .. | 0·054 | 0·261 | 2·919 | 0·981 | 0·048 | .. | .. | 4·263 |
| 24 Pellona .. .. | 0·375 | .. | 1·239 | 0·441 | 0·423 | .. | .. | 0·328 | .. | .. | .. | 0·276 | 3·082 |
| 25 Otolithus .. .. | 1·366 | .. | 0·969 | .. | .. | .. | 0·045 | .. | .. | .. | .. | .. | 2·380 |
| 26 Diagramma .. .. | 0·226 | 0·630 | 0·195 | 0·102 | 0·162 | 0·276 | 0·105 | 0·420 | .. | .. | 0·018 | .. | 2·134 |
| 27 Balistes .. .. | .. | 0·879 | 0·222 | 0·078 | .. | .. | .. | .. | .. | .. | .. | .. | 1·179 |
| 28 Histiophorus .. | 0·034 | 0·381 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·027 | 0·442 |
| 29 Mackerel .. .. | .. | .. | .. | 0·366 | .. | .. | .. | .. | .. | .. | .. | .. | 0·366 |
| 30 Albula .. .. | .. | .. | .. | .. | .. | .. | .. | 0·120 | 0·159 | .. | .. | .. | 0·279 |
| 31 Hilsa .. .. | .. | .. | .. | .. | .. | .. | .. | 0·222 | .. | .. | .. | .. | 0·222 |
| 32 Elacate .. .. | .. | 0·036 | .. | .. | .. | 0·114 | .. | .. | .. | .. | .. | .. | 0·150 |
| Total weight .. | 13·797 | 41·040 | 79·418 | 92·148 | 53·959 | 79·913 | 89·682 | 428·047 | 893·077 | 180·528 | 22·580 | 25·883 | 2,000·072 |

## TABLE V.

*Showing the total monthly landings in each variety of fish during the year 1962 in tonnes at Cape Comorin.*

| *Serial number and varieties.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) | *Total.* (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Anchoviella .. .. | .. | .. | 0·585 | 0·108 | 0·150 | 5·322 | 18·300 | 66·525 | 152·684 | 88·717 | 4·547 | 0·498 | 337·436 |
| 2 Trichiurus .. .. | 0·136 | 0·045 | 0·315 | 0·093 | 0·333 | 1·701 | 61·827 | 153·987 | 2·472 | 11·913 | 0·180 | 0·117 | 233·119 |
| 3 Lactarius .. .. | 0·090 | 0·033 | 0·009 | 0·012 | 0·063 | 0·024 | .. | 1·296 | 2·364 | 99·552 | 0·354 | 0·267 | 104·064 |
| 4 Serranus .. .. | 0·114 | 6·018 | 21·392 | 8·211 | 10·875 | 9·909 | 3·855 | 1·395 | 0·732 | 0·024 | .. | 1·326 | 63·851 |
| 5 Dussumieria .. .. | .. | .. | 1·074 | .. | 0·036 | 0·684 | 45·024 | 0·323 | 4·332 | 1·176 | 1·644 | 1·284 | 55·577 |
| 6 Lethrinus .. .. | 0·404 | 7·812 | 14·508 | 18·609 | 1·119 | 1·299 | 0·402 | 0·411 | 0·102 | 0·195 | 0·618 | 7·587 | 53·066 |
| 7 Aprion .. .. | .. | 2·073 | 21·564 | 14·028 | 6·993 | .. | .. | .. | .. | .. | .. | .. | 44·658 |
| 8 Caranx .. .. | 0·414 | 0·333 | 0·846 | 0·597 | 1·569 | 14·109 | 2·814 | 5·264 | 5·418 | 7·169 | 2·666 | 1·293 | 42·492 |
| 9 Arius .. .. | 1·347 | 0·531 | 1·503 | 1·422 | 0·162 | 3·285 | 2·370 | 3·171 | 4·284 | 1·353 | 0·807 | 2·814 | 23·049 |
| 10 Sardinella .. .. | .. | .. | .. | 0·843 | 4·690 | 6·861 | 2·061 | .. | 4·838 | 0·804 | 1·524 | 0·696 | 22·317 |
| 11 Sciaena .. .. | 9·054 | 0·651 | 0·447 | 0·153 | 0·276 | 0·039 | 0·315 | 0·282 | 2·658 | 5·139 | 0·699 | 1·401 | 21·114 |
| 12 Lutjanus .. .. | 0·132 | 1·593 | 7·062 | 5·091 | 3·042 | 0·243 | 0·264 | 0·090 | 0·572 | 0·290 | 0·549 | 0·644 | 19·572 |
| 13 Cybium .. .. | 5·289 | 0·456 | 0·030 | .. | 0·027 | .. | .. | 0·039 | 0·474 | 1·920 | 2·790 | 5·286 | 16·311 |
| 14 Leiognathus .. .. | 0·770 | 1·431 | 2·329 | 0·579 | 0·147 | 0·126 | .. | .. | .. | .. | 2·726 | 2·196 | 10·305 |
| 15 Sphyraena .. .. | 0·009 | 0·090 | 0·102 | 0·016 | 0·186 | 0·237 | 0·510 | 0·042 | 0·753 | 6·000 | 1·311 | 1·008 | 10·296 |
| 16 Sharks, skates and rays. | 2·247 | 1·080 | 1·194 | 0·615 | 0·477 | 2·118 | 1·188 | 0·687 | 0·366 | 1·155 | 0·819 | 1·692 | 13·338 |
| 17 Stromateus .. .. | 1·185 | 1·935 | 0·864 | 1·314 | 0·111 | 0·099 | 0·204 | 0·150 | 0·081 | 2·057 | 0·309 | 1·209 | 9·518 |
| 18 Chirocentrus .. | 0·567 | 0·169 | 0·446 | 0·516 | 0·027 | 0·027 | .. | .. | 0·420 | 1·902 | 3·852 | 0·981 | 8·907 |
| 19 Balistes .. .. | 1·152 | 3·765 | 1·704 | 0·435 | .. | .. | .. | .. | .. | .. | .. | .. | 7·056 |
| 20 Diagramma .. .. | 0·015 | 0·081 | 0·177 | 4·311 | 0·015 | 0·075 | 0·072 | 0·002 | 0·297 | .. | .. | 0·614 | 5·759 |
| 21 Chorinemus .. .. | 0·990 | 0·369 | 0·713 | 0·375 | 0·060 | 0·618 | 0·042 | 0·036 | .. | 0·210 | 0·579 | 1·709 | 5·701 |
| 22 Megalaspis .. .. | 0·168 | .. | 0·948 | 0·792 | 0·057 | 0·021 | .. | .. | 0·105 | 1·476 | 0·387 | 0·831 | 4·785 |
| 23 Mackerel .. .. | .. | .. | .. | .. | 0·117 | .. | 0·342 | .. | 1·083 | 2·154 | 0·950 | 0·096 | 4·742 |
| 24 Pristipoma .. .. | 0·942 | 0·012 | 0·171 | 0·165 | .. | .. | 0·333 | .. | .. | 1·728 | 0·426 | 0·702 | 4·479 |
| 25 Upeneoides .. .. | 0·018 | .. | 0·099 | 0·027 | 0·087 | .. | .. | .. | 2·121 | 1·047 | 0·339 | 0·321 | 4·059 |
| 26 Pellona .. .. | .. | .. | .. | .. | 0·099 | .. | .. | 0·067 | .. | .. | .. | 1·032 | 1·198 |
| 27 Hilsa .. .. | .. | .. | .. | 0·108 | 0·478 | 0·204 | .. | .. | .. | .. | .. | .. | 0·790 |
| 28 Decapterus .. .. | .. | .. | .. | .. | .. | .. | 0·606 | .. | .. | .. | .. | .. | 0·606 |
| 29 Histiophorus .. | 0·060 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·228 | 0·306 | 0·594 |
| 30 Elacate .. .. | .. | .. | 0·024 | .. | .. | 0·030 | 0·207 | 0·033 | .. | .. | .. | .. | 0·114 |
| 31 Thynnus .. .. | .. | .. | 0·057 | 0·021 | .. | 0·015 | .. | .. | .. | .. | .. | .. | 0·093 |
| 32 Albula .. .. | .. | .. | .. | 0·012 | 0·012 | 0·057 | .. | .. | .. | .. | .. | .. | 0·081 |
| **Total weight** .. | 26·134 | 28·477 | 77·643 | 58·503 | 31·208 | 47·103 | 140·556 | 233·900 | 166·138 | 235·981 | 28·304 | 35·910 | 1,130·347 |

## TABLE VI.

*Showing the total monthly landings in each variety of fish during the year 1963 in Tonnes at Cape Comorin.*

| *Serial number and varieties.* (1) | *January.* (2) | *February.* (3) | *March.* (4) | *April.* (5) | *May.* (6) | *June.* (7) | *July.* (8) | *August.* (9) | *September.* (10) | *October.* (11) | *November.* (12) | *December.* (13) | *Total.* (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Trichiurus .. .. | 0·097 | 0·291 | 0·578 | 0·594 | 1·962 | 2·601 | 25·210 | 313·341 | 24·855 | 3·100 | 0·786 | 0·345 | 373·760 |
| 2 Anchoviella .. .. | 0·077 | 0·063 | .. | .. | 2·967 | 29·175 | 46·965 | 37·335 | 164·049 | 65·276 | 5·985 | .. | 351·892 |
| 3 Lactarius .. .. | 0·111 | 0·229 | 1·083 | 0·678 | 0·522 | 0·564 | 0·882 | 5·331 | 57·828 | 102·035 | 8·766 | 1·050 | 179·079 |
| 4 Lethrinus .. .. | 11·788 | 14·567 | 23·361 | 25·422 | 14·583 | 2·955 | 2·364 | 0·639 | 0·495 | 0·723 | 1·103 | 4·395 | 102·377 |
| 5 Serranus .. .. | 3·617 | 11·418 | 17·796 | 15·846 | 10·608 | 15·669 | 3·495 | 1·518 | 0·498 | 0·193 | 1·659 | 0·189 | 82·686 |
| 6 Dussumieria .. | 0·126 | 0·273 | 0·552 | 0·195 | 0·567 | 45·822 | 10·146 | 0·501 | 6·705 | 0·915 | 3·510 | 1·140 | 70·452 |
| 7 Arius .. .. | 0·654 | 0·585 | 0·759 | 0·843 | 0·732 | 2·958 | 6·060 | 2·052 | 2·376 | 31·749 | 2·610 | 10·554 | 61·923 |
| 8 Caranx .. .. | 1·450 | 1·287 | 2·364 | 1·653 | 1·908 | 5·442 | 7·149 | 8·631 | 7·797 | 14·424 | 4·124 | 1·809 | 58·038 |
| 9 Lutjanus .. .. | 1·638 | 5·523 | 19·587 | 14·920 | 10·449 | 0·192 | 0·033 | 0·009 | .. | 0·075 | 0·093 | .. | 52·319 |
| 10 Sharks, skates and rays. | 3·689 | 2·400 | 2·409 | 2·201 | 2·505 | 3·456 | 15·345 | 17·830 | 4·777 | 10·735 | 1·563 | 3·267 | 60·177 |
| 11 Leiognathus .. | 1·797 | 2·132 | 2·010 | 1·200 | 0·555 | 0·300 | 0·345 | .. | .. | 1·812 | 10·995 | 7·446 | 28·592 |
| 12 Sardinella .. .. | 0·057 | .. | 0·018 | 0·867 | 3·645 | 4·775 | .. | .. | 0·048 | 5·634 | 4·113 | 0·411 | 19·568 |
| 13 Cybium .. .. | 1·527 | 0·420 | 0·567 | 0·126 | 0·249 | 0·114 | 2·817 | 0·321 | 0·435 | 2·306 | 3·900 | 4·479 | 17·261 |
| 14 Aprion .. .. | .. | .. | 6·432 | 7·917 | 2·772 | .. | .. | .. | .. | .. | .. | .. | 17·121 |
| 15 Stromateus .. .. | 0·360 | 0·006 | 0·588 | 3·064 | 0·987 | 3·897 | 0·612 | 0·069 | 2·246 | 1·671 | 0·435 | 0·669 | 14·604 |
| 16 Chironcentrus .. | 0·161 | 0·262 | 0·462 | 0·105 | 0·159 | 0·477 | 0·087 | .. | 0·186 | 0·837 | 7·329 | 0·369 | 10·434 |
| 17 Megalaspis .. .. | 2·249 | 0·249 | 1·278 | 0·711 | 0·381 | .. | .. | .. | .. | 0·798 | 1·872 | 3·501 | 9·039 |
| 18 Sciæno .. .. | 0·594 | 0·192 | 0·177 | 0·429 | 0·138 | 1·309 | 0·795 | 0·327 | 1·236 | 1·677 | 0·216 | 1·950 | 8·040 |
| 19 Sphyræna .. .. | 0·123 | 0·159 | .. | 0·102 | 0·381 | 0·576 | 0·264 | 0·090 | 0·855 | 2·430 | 0·810 | 0·405 | 6·195 |
| 20 Chorinemus .. .. | 0·342 | 0·846 | 1·263 | 0·738 | 0·387 | 0·168 | 0·036 | 0·137 | 0·027 | 0·555 | 0·471 | 1·122 | 6·092 |
| 21 Upeneoides .. .. | .. | .. | 0·135 | 0·696 | 0·027 | 0·150 | .. | 0·063 | 2·718 | 2·739 | 0·483 | 0·432 | 7·443 |
| 22 Pristipoma .. .. | 0·441 | 0·243 | 0·306 | 0·108 | .. | 0·051 | 0·060 | 0·246 | 0·263 | 0·822 | 0·516 | 1·068 | 4·124 |
| 23 Pellona .. .. | .. | .. | .. | 0·060.. | 0·045 | .. | 0·206 | .. | .... | .. | 1·355 | 1·185 | 2·851 |
| 24 Diagramma .. .. | 0·099 | 0·063 | .. | .. | 0·087 | 0·120 | .. | 0·351 | 0·834 | 0·084 | 0·039 | .. | 1·677 |
| 25 Albula .. .. | .. | .. | 0·033 | .. | .. | .. | 0·777 | 0·387 | .. | 0·186 | 0·024 | .. | 1·407 |
| 26 Hilsa .. .. | .. | .. | 0·036 | 0·219 | 0·315 | 0·102 | 0·249 | .. | .. | .. | .. | .. | 0·921 |
| 27 Balistes .. .. | 0·069 | .. | 0·459 | 0·042 | .. | .. | .. | .. | .. | .. | .. | .. | 0·570 |
| 28 Elacate .. .. | .. | .. | 0·222 | 0·048 | .. | 0·228 | .. | .. | .. | .. | .. | .. | 0·498 |
| 29 Histiophorus .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0·099 | 0·090 | 0·189 |
| 30 Mugil .. .. | .. | .. | .. | 0·132 | 0·057 | .. | .. | .. | .. | .. | .. | .. | 0·189 |
| 31 Thynnus .. .. | .. | .. | .. | .. | .. | .. | .. | 0·174 | .. | .. | .. | .. | 0·174 |
| Total weight .. | 29·066 | 41·008 | 82·655 | 78·916 | 56·088 | 121·101 | 123·879 | 377·352 | 278·228 | 250·776 | 62·847 | 45·876 | 1,549·752 |

### TABLE VII.

*Showing the annual landings in Tonnes of different varieties of fishes at Cape Comorin during the year 1958 to 1963.*

| *Serial number and name of fish.* (1) | 1958. (2) | 1959. (3) | 1960. (4) | 1961. (5) | 1962. (6) | 1963. (7) | *Total.* (8) | *Average.* (9) |
|---|---|---|---|---|---|---|---|---|
| 1 Trichiurus .. .. | 724·100 | 607·090 | 233·249 | 755·387 | 233·119 | 373·760 | 2,926·705 | 487·784 |
| 2 Anchoviella .. .. | 800·977 | 561·186 | 445·208 | 306·902 | 337·436 | 351·892 | 2,803·601 | 467·267 |
| 3 Lactarius .. .. | 244·113 | 176·981 | 262·322 | 337·662 | 104·064 | 179·079 | 1,304·221 | 217·370 |
| 4 Caranx .. .. | 397·647 | 151·521 | 82·502 | 208·208 | 42·492 | 58·038 | 940·408 | 156·734 |
| 5 Dussumieria .. | 94·522 | 115·862 | 120·276 | 38·875 | 55·577 | 70·452 | 495·564 | 82·594 |
| 6 Serranus .. .. | 38·171 | 45·183 | 19·930 | 55·010 | 63·851 | 82·686 | 304·831 | 50·805 |
| 7 Lethrinus .. .. | 20·659 | 23·613 | 12·000 | 14·283 | 53·066 | 102·377 | 225·998 | 37·666 |
| 8 Arius .. .. | 27·114 | 34·463 | 45·359 | 20·651 | 23·049 | 61·923 | 212·559 | 35·427 |
| 9 Sharks, skates and rays. | 57·083 | 20·840 | 24·544 | 27·099 | 13·338 | 60·177 | 203·081 | 33·847 |
| 10 Sardinella .. .. | 34·478 | 12·773 | 49·729 | 28·534 | 22·371 | 19·568 | 167·399 | 27·899 |
| 11 Lutjanus .. .. | 3·512 | 6·632 | 6·583 | 43·437 | 19·572 | 52·319 | 132·055 | 22·009 |
| 12 Cybium .. .. | 36·233 | 30·706 | 19·930 | 55·010 | 63·851 | 82·686 | 304·831 | 50·805 |
| 13 Leiognathus .. | 11·748 | 22·818 | 6·938 | 37·490 | 10·305 | 28·592 | 117·891 | 19·648 |
| 14 Sciæna .. .. | 13·118 | 16·617 | 23·875 | 30·236 | 21·114 | 8·040 | 113·000 | 18·893 |
| 15 Aprion .. .. | 9·023 | 19·364 | 5·910 | 9·330 | 44·658 | 17·121 | 105·406 | 17·559 |
| 16 Stromateus .. .. | 17·196 | 10·961 | 12·416 | 12·661 | 9·518 | 14·604 | 77·356 | 12·893 |
| 17 Sphyræna .. .. | 12·114 | 13·751 | 4·383 | 12·460 | 10·296 | 6·195 | 59·199 | 9·866 |
| 18 Chorinemus .. .. | 9·307 | 13·579 | 11·121 | 6·980 | 5·701 | 6·092 | 52·780 | 8·797 |
| 19 Decapterus .. .. | 21·898 | .. | 20·008 | .. | 0·606 | .. | 42·512 | ·085 |
| 20 Megalaspis .. .. | 2·663 | 7·886 | 10·122 | 6·218 | 4·785 | 9·039 | 40·713 | 6·785 |
| 21 Chirocentrus .. .. | 2·569 | 1·844 | 3·118 | 6·652 | 8·907 | 10·434 | 33·524 | 5·587 |
| 22 Upeneoides .. .. | 2·417 | 5·005 | 3·465 | 6·596 | 4·059 | 7·443 | 28·985 | 4·831 |
| 23 Balistes .. .. | 10·363 | 5·387 | 2·114 | 1·179 | 7·056 | 0·570 | 26·669 | 4·445 |
| 24 Pristipoma .. .. | 3·266 | .. | .. | 9·084 | 4·479 | 4·124 | 20·953 | 3·492 |
| 25 Diagramma .. .. | 1·105 | 3·454 | 0·951 | 2·134 | 5·759 | 1·677 | 15·080 | 2·513 |
| 26 Mackerel .. .. | .. | 0·773 | 7·242 | 0·366 | 4·742 | .. | 13·123 | 2·187 |
| 27 Pellona .. .. | 0·273 | 1·478 | 1·709 | 3·082 | 1·198 | 2·851 | 10·591 | 1·765 |
| 28 Drepane .. .. | 2·761 | 2·046 | 1·098 | 4·263 | .. | .. | 10·168 | 1·694 |
| 29 Otolithus .. .. | 1·306 | 1·477 | 2·346 | 2·380 | .. | .. | 7·509 | 1·251 |
| 30 Histiophorus .. | 1·478 | 0·749 | 1·248 | 0·442 | 0·594 | 0·189 | 4·700 | 0·783 |
| 31 Albula .. .. | .. | .. | 0·770 | 0·279 | 0·081 | 1·407 | 2·537 | 0·423 |
| 32 Hilsa .. .. | .. | .. | .. | 0·222 | 0·790 | 0·921 | 1·933 | 0·322 |
| 33 Elacate .. .. | 0·055 | 0·224 | 0·757 | 0·150 | 0·114 | 0·498 | 1·798 | 0·299 |
| 34 Mullets .. .. | 0·250 | 0·555 | 0·118 | .. | .. | 0·189 | 1·112 | 0·185 |
| 35 Thynnus .. .. | .. | .. | .. | .. | 0·093 | 0·174 | ·267 | 0·044 |
| Total .. | 2,601·519 | 1,914·818 | 1,440·417 | 2,000·072 | 1,130·347 | 1,549·752 | 10,636·925 | 1,772·821 |

## TABLE VIII.

*Showing the total and peak season landings, maximum and minimum monthly landings and the important peak season fishery during six year period.*

| *Year.* (1) | *Total landing in tonnes.* (2) | *Landings from June to October in tonnes.* (3) | *Maximum monthly landings in tonnes/month.* (4) | *Minimum monthly landings in tonnes/month.* (5) | *Important fishery during peak season.* (6) |
|---|---|---|---|---|---|
| 1958 .. .. .. .. | 2,601·519 | 2,141·262 | 604·180 (July). | 22·069 (December). | Anchoviella, Trichiurus, Caranx, Lactarius and Dussumieria. |
| 1959 .. .. .. .. | 1,914·818 | 1,636·910 | 801·004 (September). | 16·759 (May). | Trichiurus, Anchoviella, Lactarius, Caranx and Dussumieria. |
| 1960 .. .. .. .. | 1,440·417 | 1,227·608 | 482·652 (October). | 15·355 (February). | Anchoviella, Lactarius, Trichiurus, Dussumieria and Caranx. |
| 1961 .. .. | 2,000·072 | 1,671·247 | 893·077 (September) | 13·797 (January) | Trichiurus, Lactarius, Anchoviella and Caranx. |
| 1962 .. .. .. .. | 1,130·347 | 823·678 | 235·981 (October). | 26·134 (January). | Anchoviella, Trichiurus Lactarius, Dussumieria and Caranx. |
| 1963 .. .. .. .. | 1,549·752 | 1,152·108 | 379·352 (August). | 29·066 (January). | Trichiurus, Anchoviella, Lactarius, Dussumieria, Arius and Caranx. |

## TABLE IX.

*Showing the maximum, minimum and average annual landings, percentage of total landings and the months of peak fishery of each variety of fish during six-year period.*

| *Serial number and name of fish.* (1) | *Average annual landings in tonnes.* (2) | *Approximate-percentage of total landings.* (3) | *Range of landings in tonnes.* *Maximum. year.* (4) | *Minimum. year.* (5) | *Months of peak fishery.* (6) |
|---|---|---|---|---|---|
| 1 Trichiurus .. .. .. | 487·784 | 27·5 | 755·387 (1961). | 233·119 (1962). | July to October. Available in small quantities almost right through the year. |
| 2 Anchoviella .. .. | 467·267 | 26·0 | 800·977 (1958). | 306·902 (1961). | July to October. |
| 3 Lactarius .. .. .. | 217·370 | 12·0 | 337·662 (1961). | 104·064 (1962). | September to October. Small quantities right through the year. |
| 4 Caranx .. .. .. | 156·734 | 8·8 | 397·647 (1958). | 42·492 (1962). | June to October. Small quantities right through the year. |
| 5 Dussumieria .. .. | 82·594 | 4·0 | 120·276 (1960). | 38·875 (1961). | June to September. |
| 6 Serranus .. .. .. | 50·805 | 2·9 | 82·686 (1963). | 19·930 (1960). | February to June. |
| 7 Lethrinus .. .. .. | 37·666 | 2·1 | 102·377 (1963). | 12·000 (1960). | February to May. |
| 8 Arius .. .. .. | 35·427 | 2·0 | 61·923 (1963). | 20·651 (1961). | September to December. |
| 9 Sharks, skates and rays. | 33·847 | 1·9 | 60·177 (1963). | 13·338 (1962). | July to October, Almost right through the year in small quantities. |
| 10 Sardinella .. .. .. | 27·899 | 1·6 | 49·729 (1960). | 12·773 (1959). | July to October. In small quantities right through the year. |
| 11 Lutjanus .. .. .. | 22·009 | 1·2 | 52·319 (1963). | 3·512 (1958). | February to May. |

TABLE IX—*cont.*

*Showing the maximum, minimum and average annual landings, percentage of total landings and the months of peak fishery of each variety of fish during six-year period*—cont.

| *Serial number and name of fish.* | *Average annual landings in tonnes.* | *Approximate percentage of total landings.* | *Range of landings in tonnes.* | | *Months of peak fishery.* |
|---|---|---|---|---|---|
| | | | *Maximum. year.* | *Minimum. year.* | |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 12 Cybium .. .. .. | 21·939 | 1·2 | 36·233 (1958). | 11·820 (1961). | October to February. |
| 13 Leiognathus .. .. | 19·648 | 1·1 | 37·490 (1961). | 6·938 (1960.) | November to April. |
| 14 Sciaena .. .. .. | 18·833 | 1·0 | 30·236 (1961). | 8·040 (1963). | September to January. |
| 15 Aprion .. .. .. | 17·559 | 0·99 | 44·658 (1962). | 5·910 (1960). | February to April. |
| 16 Stromateus .. .. | 12·893 | 0·72 | 17·196 (1958). | 9·518 (1962). | July to September. In small quantities right through the year. |
| 17 Sphyraena .. .. .. | 9·866 | 0·55 | 13·751 (1959). | 4·383 (1960). | September to October. Right through the year in small quantities. |
| 18 Chorinemus .. .. | 8·797 | 0·49 | 13·579 (1959). | 5·701 (1962). | December to May. |
| 19 Decapterus.. .. .. | 7·085 | 0·39 | 21·898 (1958). | Nil. (1959, 1961 and 1963). | August to September. |
| 20 Megalaspis .. .. .. | 6·785 | 0·38 | 10·122 (1960). | 2·663 (1958). | October to April. |
| 21 Chirocentrus .. .. | 5·587 | 0·31 | 10·434 (1963). | 1·844 (1959). | October to December. |
| 22 Upeneoides .. .. .. | 4·831 | 0·27 | 7·443 (1963). | 2·417 (1958). | September to December and February to April. |
| 23 Balistes .. .. .. | 4·445 | 0·25 | 10·363 (1958). | 0·57 (1963). | January to April. |
| 24 Pristipoma .. .. | 3·942 | 0·22 | 9·084 (1961). | Nil (1959 and 1960). | October to May. |
| 25 Diagramma .. .. | 2·513 | 0·14 | 5·759 (1961). | 0·951 (1960). | No marked season. Right through the year. |
| 26 Mackerel .. .. .. | 2·187 | 0·12 | 7·242 (1960). | Nil. (1958 and 1963). | August to November. |
| 27 Pellona .. .. .. | 1·765 | 0·09 | 3·098 (1961). | 0·273 (1958). | November to May. |
| 28 Drepane .. .. .. | 1·694 | 0·09 | 4·263 (1961). | Nil. (1962 and 1963). | June to October. |
| 29 Otolithus .. .. .. | 1·251 | 0·07 | 2·346 (1960). | Nil. (1962 and 1963). | January to October. |
| 30 Histiophorus .. .. | 0·783 | 0·04 | 1·478 (1958). | 0·189 (1963). | November to February. |
| 31 Albula .. .. .. | 0·423 | 0·02 | 1·407 (1963). | Nil. (1958 and 1959). | No marked season. |
| 32 Hilsa] .. .. .. | 0·322 | 0·02 | 0·921 (1963). | Nil. (1958, 1959 and 1960). | March to August. |
| 33 Elacate .. .. .. | 0·299 | 0·01 | 0·757 (1960). | 0·065 (1958). | No marked season. |
| 34 Mullets .. .. .. | 0·185 | 0·01 | 0·555 (1959). | Nil. (1961 and 1962). | April to May. |
| 35 Thynnus .. .. .. | 0·044 | .. | 0·174 (1958). | Nil. (1958, 1959, 1960 and 1961). | August. |

## TABLE X.

*Showing the Fishery Calendar for Cape Comorin.*

| *Serial number.*<br>(1) | *January.*<br>(2) | *February.*<br>(3) | *March.*<br>(4) | *April.*<br>(5) | *May.*<br>(6) | *June.*<br>(7) |
|---|---|---|---|---|---|---|
| 1 | Cybium | Lethrinus | Serranus | Serranus | Caranx | Anchoviella. |
| 2 | Sharks, skates and rays. | Serranus | Lutjanus | Lethrinus | Sardinella | Caranx. |
| 3 | Arius | Aprion | Lethrinus | Lutjanus | Serranus | Trichiurns. |
| 4 | Sciaena sp. | Cybium | Aprion | Aprion | Lethrinus | Dussumieria. |
| 5 | Lethrinus | Leiognathus | Sardinella | Sardinella | Lutjanus | Serranus. |
| 6 | Leiognathus | Balistes | Arius | Leiognathus | Lactarius | Arius. |
| 7 | Caranx | Lutjanus | Sharks, skates and rays. | Lactarius | Chorinemus | Sharks, skates and rays. |
| 8 | Serranus | Caranx | Caranx | Caranx | Anchoviella | Lethrinus. |
| 9 | Chorinemus | Arius | Chorinemus | Sharks, skates and rays. | Aprion. | Sardinella. |
| 10 | Stromateus | Sharks, skates and rays. | Balistes | Chorinemus | Trichiurus | Stromateus. |
| 11 | Megalaspis | Stromateus | Leiognathus | Dussumieria | Sciaena | Lactarius. |
| 12 | Lactarius | Chorinemus | Megalaspis | Arius | Leiognathus | Sciaena. |
| 13 | Anchoviella | Sciaena | Pristipoma | Sciaena | Arius | Sphyraena. |
| 14 | Lutjanus | Sardinella | Cybium | Stromateus | Dussumieria | Lutjanus. |
| 15 | Sardinella | Pristipoma | Dussumieria | Diagramma | Cybium | Leiognathus. |
| 16 | Chirocentrus | Sphyraena | Lactarius | Anchoviella | Stromateus | Diagramma. |
| 17 | Aprion | Megalaspis | Sciaena | Sphyraena | Pellona | Drepane. |
| 18 | Pristipoma | Chirocentrus | Stromateus | Megalaspis | Drepane | Chorinemus. |
| 19 | Trichiurus | Anchoviella | Upeneoides | Balistes | Sphyraena | Chirocentrus. |
| 20 | Dussumieria | Trichiurus | Anchoviella | Upenoides. | Pristipoma | .... |
| 21 | Pellona | Lactarius | Trichiurus | Cybium | Hilsa | .... |
| 22 | Balistes | Diagramma | Diagramma | Trichiurus | .... | .... |
| 23 | Otolithus | Histioephorus | Pellona | Pellona | .... | .... |
| 24 | Sphyraena | Upenoides | Sphyraena | Chirocentrus | .... | .... |
| 25 | .... | Otolithus | Chirocentrus | Pristipoma | .... | .... |
| 26 | .... | .... | Otolithus | Otolithus | .... | .... |

| *Serial number.* | *July.*<br>(8) | *August.*<br>(9) | *September.*<br>(10) | *October.*<br>(11) | *November.*<br>(12) | *December.*<br>(13) |
|---|---|---|---|---|---|---|
| 1 | Trichiurus | Trichiurus | Trichiurus | Anchoviella | Anchoviella | Cybium. |
| 2 | Anchoviella | Anchoviella | Anchoviella | Lactarius | Lactarius | Leiognathus. |
| 3 | Dussumieria | Caranx | Lactarius | Trichiurus | Sardinella | Arius. |
| 4 | Caranx | Dussumieria | Caranx | Caranx | Cybium | Sciaena. |
| 5 | Sharks, skates and rays. | Sharks, skates and rays. | Dussumieria | Arius | Leiognathus | Lethrinus. |
| 6 | Arius | Decapterus | Arius | Sphyraena | Caranx | Dussumieria. |
| 7 | Serranus | Sardinella | Sharks, skates and rays. | Sharks, skates and rays. | Trichiurus | Caranx. |
| 8 | Stromateus | Arius | Decapterus | Sardinella | Arius | Megalaspis. |
| 9 | Lethrinus | Lactarius | Sciaena | Dussumieria | Dussumieria | Sharks, skates and rays. |
| 10 | Sardinella | Stromateus | Sphyraena | Sciaena | Chirocentrus | Anchoviella. |
| 11 | Cybium | Lethrinus | Upeneoides | Cybium | Sharks, skates and rays. | Sardinella. |
| 12 | Lactarius | Serranus | Stromateus | Stromateus | Megalaspis | Chorinemus. |
| 13 | Sciaena | Mackerel | Sardinella | Upenoides | Sciaena | Trichiurus. |
| 14 | Sphyraena | Sciaena | Leiognathus | Chirocentrus | Stromateus | Lactarius. |
| 15 | Leiognathus | Drepane | Cybium | Leiognathus | Lethrinus | Stromateus. |
| 16 | Diagramma | Chirocentrus | Serranus | Megalaspis | Upeneoides | Pellona. |
| 17 | Drepane | Lutjanus | Chirocentrus | Pristipoma | Sphyraena | Sphyraena. |
| 18 | Mackerel | Cybium | Drepane | Marckerel | Serranus | Pristipoma. |
| 19 | Albula | Leiognathus | Lutjanus | Otolithus | Histiophorus | Lutjanus. |
| 20 | .... | Diagramma | Lethrinus | Lethrinus | Mackerel | Serranus. |
| 21 | .... | Sphyraena | Diagramma | Serranus | Lutjanus | Diagramma. |
| 22 | .... | Albula | Pristipoma | Chorinemus | Pellona | Histiophorus. |
| 23 | .... | .... | Mackerel | .... | Drepane. | Chirocentrus. |
| 24 | .... | .... | .... | .... | Pristipoma | Upeneoides. |
| 25 | .... | .... | .... | .... | Mugil sp. | .... |
| 26 | | | | | | |

## TABLE XI.

*Showing the monthly and annual averages of the number of catamarans that went for fishing daily at Cape Comorin during the six year period* 1958–1963.

| Month. | Years. | | | | | |
|---|---|---|---|---|---|---|
| | 1958. | 1959. | 1960. | 1961. | 1962. | 1963. |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| January | 155 | 101 | 88 | 64 | 72 | 68 |
| February | 171 | 127 | 89 | 107 | 76 | 69 |
| March | 101 | 113 | 101 | 132 | 97 | 107 |
| April | 92 | 85 | 102 | 117 | 82 | 99 |
| May | 102 | 91 | 94 | 127 | 91 | 92 |
| June | 147 | 141 | 141 | 124 | 124 | 182 |
| July | 246 | 156 | 120 | 157 | 169 | 194 |
| August | 273 | 220 | 171 | 228 | 188 | 275 |
| September | 261 | 278 | 149 | 300 | 169 | 233 |
| October | 221 | 196 | 174 | 133 | 158 | 214 |
| November | 96 | 78 | 85 | 76 | 97 | 156 |
| December | 93 | 117 | 84 | 94 | 102 | 115 |
| Average | 163 | 142 | 116 | 138 | 119 | 150 |

TABLE XII.

*Showing the peak seasons of the important fisheries of Cape Comorin during the six year period.*

| *Serial number.* (1) | *Name of fishery.* (2) | 1958. (3) | 1959. (4) | 1960. (5) | 1961. (6) | 1962. (7) | 1963. (8) |
|---|---|---|---|---|---|---|---|
| 1 | Trichiurus | June to September. | August to October. | July, August and October. | July to October. | July and August. | July to September. |
| 2 | Anchoviella | June to October. | July to October. | June to October. | August to October. | August to October. | June to October. |
| 3 | Lactarius | September and October. | September and October. | September and October. | October .. | September and October. | September and October. |
| 4 | Caranx | May to October. | June to October. | May to September. | August and September. | June to October (Poor). | June to October (Poor). |
| 5 | Dussumieria | July and September. | June to October. | June to August. | June .. | July .. | June and July. |
| 6 | Serranus | March to June. | February to April. | March and April. | February to July. | February to July. | January to July. |
| 7 | Lethrinus | February and March. | February to April. | March .. | February .. | December and February to April. | December to July. |
| 8 | Arius | January, February, July, August and October. | January, July, September and November. | January, July and September. | March, June, July and November. | June to September. | June to December. |
| 9 | Sharks, skates and rays | January and July to September. | Poor | July .. | March and June to September. | Poor .. | July to October. |
| 10 | Sardinella | March to May and August. | April, May and October to December (Poor). | March to May, October and November. | April, May and October. | May, June, July and September. | November and December. |
| 11 | Lutjanus | April .. | April .. | March and April. | February, March and April. | March, April and May. | February to May. |
| 12 | **Cybium** | January, February and October to December. | January to March and October to December. | February and October to December. | January, February and December. | January and October to December. | January, July and October to December. |

# ON THE CHEMICAL QUALITY OF COMMON SALT USED IN THE FISH CURING INDUSTRY IN MADRAS STATE

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## Synopsis

The chemical quality of the Common salt used in different sections of the fish curing industry in Madras State, namely Government fish curing yards, private fish curing yards and fishery salts produced by the salt manufacturers in the State were tested over a period of seven years from 1957 to 1964 and compared with the Indian Standard Specification for common salt for fish curing I.S. 594–1954 (tentative) and I.S. : 594–1962 (revised). None of the salt samples used in Government and private fish curing yards satisfied the revised standard I.S. : 594–1962 (98 per cent Na Cl) and only 96·89 per cent of the salt samples in Government fish curing yards were up to the tentative standard I.S. : 594–1954 (98 per cent Na Cl). Only one of the 4 salt samples examined from the private fish curing yards satisfied the tentative 1954 standard. Only 5·13 per cent of the market samples, not the revised specification, and only 7·7 per cent of the market samples were within the tentative standards. The scarcity in the market of the salt of required specifications is found to be the chief cause for the use of low-grade salt in fish curing in the State and this will have to be remedied first to improve the quality of salt used in fish curing.

## Instructions

Salt-curing of fish is the most important method of fish preservation in Madras State, accounting for nearly 42 per cent of the total marine fish landing in the State. The scattered distribution of the fishing hamlets all along the coast and their improper communication links with the inland places have compelled the fishermen from time immemorial to preserve a major portion of their daily catches by traditional methods of salt-curing. The salt-cured and dried fish has a good demand in the internal markets as well as in Ceylon and other South-East Asian countries and Africa, not only as a source of protein, but also as a strongly flavoured food used in making less tasty items more palatable. But the quality of the salt-cured fish produced in most instances is far from satisfactory due to many reasons like the use of spoiled fish for curing, the bad quality of salt used, unhygienic methods of handling and curing, improper salting, inadequate drying, etc.

The importance of the use of good quality salt in fish curing was realised by Madras State Government as early as 1874 when they opened the Government salting enclosures (the present day fish curing yards) to discourage the use of salt-earth for fish curing and also for supplying good quality salt at a little above the cost price for *bona fide* fish curing purposes. Since the abolition of salt duty from 1947 there has been considerable decline in the utilisation of fish curing yards by fishermen, as salt is now generally available in the open market at the same rates as in Government yards. Further, since salt manufacture on small scale by individuals is now permitted, low quality salt has become easily available at very cheap rates and consequently many fish curers use salt of very inferior quality and produce cured fish of very bad quality. To meet this situation to some extent and to induce the fish curers to resort to Government fish curing yards the Madras State Government subsidises the supply of salt in their fish curing yards, but the extent of subsidy has not proved sufficiently attractive to detract the fishermen from using low-grade salt available outside the Government fish curing yards. There is also no effective check against the use of low grade salt in fish curing in private premises. V.R. Pillai, et. el. (1956), during the course of their study of the chemical quality of cured fish products of the west coast of India examined 16 samples of salt from the fish curing centres and found their Na Cl content to range from 88·88 per cent to 98·91 per cent and observed that any effort made to have an analytical check on the quality of the salt issued will go a long way in improving the quality of the cured product. Venkataraman and Sreenivasan (1935) and Venkataraman and Vasavan (1956) also made similar observations and stressed the need for using better quality salt. The bacteriology and chemical compositions of the various types of common salt available in the country with special reference to the red halophilic bacteria causing spoilage of salted fish was also studied by Venkataraman and Sreenivasan (1956). Realising the urgent need for the use of good quality salt in fish curing, the Indian Standards Institution laid down tentative specifications for common salt for fish curing in I.S.: 594–1954 and subsequently revised them in I.S. : 594–1962. The extent to which the salt used in the fish curing industry in Madras State during the period 1957 to 1964 actually conferred to these standards is briefly discussed in the present communication.

## Materials and Methods

Samples of common salt used in the Government and private fish curing yards all over the State and samples of salt offered for supply to the fish curing yards by the various salt manufacturers in the State during the seven year period 1957 to 1964 were examined for their chemical quality as a routine and data compiled. All the salt samples were tested for the various requirements like moisture, Na Cl, Insolubles and solubles like $Mg\ Cl_2$. $Ca\ Cl_2$, $Mg.\ So_4$, and $Ca\ So_4$ according to the methods prescribed in I.S. : 238–1954.

## Results and discussion

There are 21 Government fish curing yards in Madras State consuming on an average 8,000 tonnes of common salt annually for fish curing. Though the number of well-recognised private fish curing yards in the State is very limited, a lot of private fish curing takes place in private premises in the various fishing hamlets all along the coast, consuming approximately 7,060 tonnes (estimated) of salt annually. Only solar sea salts are used for fish curing in the State and are purchased by the fish curers from nearly salt manufacturers in Tuticorin (Tirunelveli district), Kanyakumari district, Thanjavur district, South Arcot district and Chingleput district.

Table I shows the summary of the results of analysis of 94 salt samples used for fish curing in the Government fish curing yards all over the State during the seven year period from 1957 to 1964. Table II shows the result of analysis of the four samples of salt used in the private fish curing yards in the State. Table III shows the summary of the results of analysis of 192 salt samples offered for fish-curing by the various salt manufacturers in the State.

It will be seen from Table I, that in the salt samples used in the Government fish curing yards, the moisture ranged from 0·13 per cent to 8·93 per cent, Na Cl from 88·02 per cent to 98·82 per cent and insolubles from 0·13 per cent to 2·76 per cent. In the private fish curing yards, the salt samples had moisture ranging from 1·23 per cent to 6·90 per cent, NaCl ranging from 80·57 per cent to 96·35 per cent and insolubles from 0·70 per cent to 2·47 per cent. The salt samples offered by the salt manufacturers for fish curing had moisture content varying from 0·09 per cent to 19·51 per cent, NaCl varying from 81·2 per cent to 99·58 per cent and insolubles from 0·92 per cent to 7·17 per cent.

The following are the specifications prescribed by the Indian Standards Institution for Common salt for fish curing :—

| | *I.S.* 594–1954 (*Tentative*). | *I.S.* 594–1962 (*Revised*). |
|---|---|---|
| | (1) | (2) |
| (i) Moisture, present by weight, maximum. | 6·0 | 6·0 |
| (ii) Sodium chloride (NaCl) per cent by weight, minimum. | 96·0 | 98·0 |
| (iii) Matter insoluble in water, per cent by weight, maximum. (On dry basis.) | 1·0 | 0·5 |
| (iv) Calcium sulphate (as $CaSo_4$), magnesium chloride (as Mg. $Cl_2$) and Magnesium sulphate (as $MgSo_4$) together per cent by weight, maximum. (On dry basis). | 3·0 | 1·5 |

NOTE.—This represents the matter soluble in water other than NaCl, per cent, by weight maximum.

The tentative standard shown in column (1) above was prescribed in 1954 and it is stated in the revised standard that as a result of experiments conducted by a number of laboratories in the country for determining the maximum impurities allowable in fish curing salt and the quality of salt available for fish curing purposes, the standard was revised in 1962. The maximum moisture allowed in both the Standards is 6·0 per cent, and it will be seen from Tables, I, II and III that 87·13 per cent of salt samples in Government fish curing yards, nearly 75 per cent of the salt samples in private fish curing yards and 72·91 per cent of the salt samples offered by salt manufacturers for fish-curing conformed to those standards.

Considering the 1954 standard of 95·0 per cent for NaCl, 46·80 per cent of the Government fish curing yard samples, nearly 25 per cent at the private fish curing yard samples and 34·37 per cent of the salt samples offered by salt manufacturers conformed to this standard. However according to the 1962 standard which prescribes a higher NaCl content of 98·0 per cent only 1·06 per cent of the Government yard samples, and 10·41 per cent of the salt samples offered by the salt manufacturers conformed to this standard. None of the private fish curing yard samples came up to this high standard.

Regarding insolubles, 51·64 per cent of the Government fish curing yard samples, nearly 50 per cent of the private fish curing yard samples and 56·41 per cent of the samples in the market satisfied the maximum limit of 1 per cent prescribed in 1954 standard. Only 25·27 per cent of the Government fish curing yard samples, and 46·15 per cent of the samples in the market reached the 1962 standard of 0·5 per cent (maximum) insolubles. None of the samples in the private fish curing yards was up to this specification.

Regarding solubles like $MgCl_2$, $MgSo_4$, $C^aSo_4$, etc., 64·4 per cent of the Government yard samples satisfied the 1954 standard of 3·0 per cent (maximum), but only 2·2 per cent of the Government yard samples could come up to the standard of 1·5 per cent (maximum) prescribed in 1962. In private fish curing yard samples, nearly 25 per cent had solubles below 3 per cent and none satisfied the standard of 0·5 per cent (maximum). 15·35 per cent of the samples in the market satisfied the 1954 standard, whereas only 5·13 per cent of the market samples satisfied the revised standards.

Considering all the requirements as a whole, it can be said that 26·89 per cent of the Government yard samples only satisfied the tentative standards, while none of the samples could come up to the revised standard. Only one of the four private fish curing yard samples examined satisfied the 1956 standard, whereas none of the samples came up to the revised standard. 7·7 per cent of the samples offered by the salt manufacturers satisfied the tentative standard, but only 5·13 per cent of the market samples came up to the 1962 standard.

Though a majority of the salt samples now used in the fish curing industry satisfied the moisture standards, they fell far below the standards required for NaCl, and insolubles. Only 5·13 per cent of the samples offered by the salt manufacturers could satisfy all the requirements. Even according to the comparatively 'lower' standards prescribed in 1954, only 7·7 per cent of the market samples satisfied all the requirements, clearly showing the present poor standards of majority of salt samples in the market. Usually salt is required at the fish curing yards at short notice with very little time for searching the high quality salt satisfying all requirements. Even in the case of Government fish curing yards, where there is a machinery for testing of the salt samples prior to purchase, difficulty is experienced in selecting the salt, as on most of the occasions none of the samples available meets all the requirements. Because of the emergency, sub-standard salt has to be purchased on such occasions. This accounts for only 46·80 per cent of Government yard samples having 96·0 per cent NaCl and 1·06 per cent only having 98·0 per cent NaCl. The conditions are worse in private fish curing. Even out of the 16 salt samples examined by V. K. Pillai, et. al. (1956), none of the samples meets the 1962 standard for all requirements and only one sample satisfies the 1954 standard.

The average NaCl content of the common salt used in the Fish Curing Industry in Madras State is compared below with the average NaCl content of the common salt used in other countries :—

| *Serial number and particulars.*<br>(1) | *Average NaCl. content.*<br>(2)<br>PER CENT. |
|---|---|
| 1 Common salt used in Government Fish Curing Yards in Madras State. | 94·86 |
| 2 Common salt used in private Fish Curing Yards in Madras State. | 89·90 |
| 3 Common salt offered by salt manufacturers for Fish Curing in Madras State. | 90·88 |
| 4 European solar salt used for fish curing .. | 95·71 (6) |
| 5 Russian solar salt used for fish curing .. .. | 97·74 (6) |
| 6 North and South American solar salt used for fish curing. | 97·30 (6) |
| 7 Solar fishery salt used in Eastern Canada .. | 97·30 (1) |

*N.B.*—(1), (6)—These numbers indicate the references in Annexure from which the figures have been taken.

These comparative figures will show that the chemical quality of the salt used in the fish curing industry in Madras State is very poor when compared with the standards prevailing in other countries. The comparatively better figures in Government fish curing yards also show that steps are being taken by Government to select the best of the salt available in the market, but these figures can reach the standard of 98 per cent NaCl prescribed in I.S. 594–1962, only if more of such good quality salt is produced in the market.

The scarcity in the market of pure common salt conforming to the I.S. 594–1962 standards should therefore be deemed as the foremost reason for the use of low grade salt in the fish curing industry at present. Steps should therefore be taken to see that all the salt manufacturers produce more of high quality salt conforming to the specifications. In view of the paucity in the market for salt of 98 per cent NaCl content, the Madras State Government is now insisting on 1954 standards only (96 per cent NaCl) for the salt used in Government fish curing yards. It is also worthwhile to conduct studies on the preparation of cured fish products by the indigenous processes like dry salting, wet salting and pit curing using salts of different NaCl contents ranging from 96 per cent to 100 per cent and find out the relative merits of each product from the point of chemical quality, consumer preference and keeping quality.

The composition of the salt used in fish curing has been found by Tressler (1930) to be of great importance, not only in affecting the rate of its penetration into the tissues of fish, but also in determining the physical qualities of the product. Though a moisture content of 6·0 per cent has been allowed in the standards. it is preferable to use comparatively dry salt with less moisture content, as high moisture content will lower the effective amount of NaCl in a given weight of salt and unless allowed for, may subsequently cause spoilage in any process where NaCl concentration is the limiting factor affecting preservations. (Shewan, 1951). According to Beatty and Fougere (1957) a good fishery salt must strike quickly and must come out of the fish readily on freshening ; it must contain little or no objectionable impurities, particularly compounds of magnesium, iron and copper; it must contain no bacteria capable of living and growing in the presence of salt ; and it must be of suitable particle size. Calcium and magnesium impurities generally tend to slow up the striking and the freshening out of the fish before cooking. Shewan (1951 loc.cited) has stated that in higher temperatures of the trophical countries and with thicker flesh of 4 to 5 cms. the penetrations of NaCl may be so retarded by the Ca and Mg impurities that spoilage of the inner flesh may occur producing " putty fish ". Though the presence of gypsum up to one per cent, has been found to produce whiter and more attractive cured fish, French and Russian workers have shown that the maximum, concentration of allowable impurities for dry salting was 0·5 per cent Ca iron, 0·6 per cent Mg. iron and one per cent sulphate (Shewan 1951). The average figures for those impurities in Table I show that common salt used in Government fish curing yards were mostly within these limits.

The average " Insolubles " figures for the Government fish curing yard samples, private fish curing yard samples and market samples are respectively, 1·16 per cent. 1·32 per cent and 1·43 per cent as against the tentative standard of 1·0 per cent and revised standard of 0·5 per cent indicating good scope for further reduction of insolubles. Immediate measures for reduction of the insolubles and increase of the NaCl content of all common salt produced in the State will go a long way in improving the quality of common salt used in the fish curing industry in the State.

## *Summary.*

The chemical quality of the common salt used in different sections of the fish curing industry in Madras State, namely, Government fish curing yards, private fish curing yards and fishery salts produced by the salt manufacturers in the State was tested over a period of seven years from 1957 to 1964 and compared with the Indian Standard Specification for common salt for fish curing I.S. 594–1954 (Tentative) and I.S. 594–1962 (revised). None of the salt samples used in Government and private fish cuing yards satisfied the revised standard I.S. 594–1962 (98 per cent NaCl) and only 26·89 per cent of the salt samples in Government fish curing yards were up to the tentative standard I.S. 594–1954 (96 per cent NaCl). Only one of the four salt samples examined from the private fish curing yards satisfied the tentative 1954 standard. Only 5·13 per cent of the market samples, met the revised specifications, and only 7·7 per cent of the market samples were within the tentative standards. The scarcity in the market of the salt of required specifications is found to be the chief cause for the use of low-grade salt in fish curing in the State and this will have to be remedied first to improve the quality of salt used in fish curing. The moisture content and the

Ca, Mg and So4, impurities were found to be within the limits allowed in most of the samples, but the chief defects were found to be high insolubles and low NaCl content. The average NaCl contents of the salt samples in Government fish curing yards, private fish curing yards and the fishery salt trade were found to be respectively 94·86 per cent, 89·99 per cent and 90·88 per cent and should be considerably improved. The average figures for "insolubles" in the samples of Government fish curing yards, private fish curing yards and salt manufacturers were 1·16 per cent, 1·32 per cent and 1·43 per cent respectively and should be reduced considerably to reach the revised standard of 0·5 per cent.

## *Acknowledgments.*

We are thankful to the Director of Fisheries, Madras, for his kind permission to publish this paper.

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TABLE I.

*Showing the summary of the results of analysis of common salt used in Government fish curing yards in Madras State during the years* 1957–64.

| *Serial number and particulars.* (1) | *Moisture.* (2) PER CENT. | *On dry basis.* | | | | | |
|---|---|---|---|---|---|---|---|
| | | $NaCl_2$ (3) PER CENT. | *Insolubles* (4) PER CENT. | *MgC12* (5) PER CENT. | *CaC12* (6) PER CENT. | *MgSo4* (7) PER CENT. | *CaSo4* (8) PER CENT. |
| 1 Number of samples examined .. .. .. | 94 | 94 | 91 | 90 | 65 | 60 | 91 |
| 2 Range observed— | | | | | | | |
| Maximum .. .. .. .. .. .. .. | 0·13 | 88·02 | 0·13 | 0·05 | 0·01 | 0·04 | 0·37 |
| Minimum .. .. .. ... .. .. .. | 2·93 | 98·82 | 2·76 | 2·18 | 0·98 | 1·81 | 3·02 |
| 3 Average .. .. .. .. .. .. .. | 4·26 | 94·86 | 1·16 | 0·61 | 0·32 | 0·47 | 1·58 |
| 4 Number of samples conforming to I.S. : 594—1954 .. | 82 | 44 | 47 | 58 | | | |
| 5 Per centage of samples conforming to I.S. 594—1954 .. | 87·13 | 46·80 | 51·64 | 64·4 | | | |
| 6 Number of samples conforming to I.S. : 594—1962 .. | 82 | 1 | 23 | 2 | | | |
| 7 Percentage of samples conforming to I.S. : 594—1962 .. | 87·13 | 1·06 | 25·27 | 2·2 | | | |
| 8 Percentage of samples conforming to I.S. 584—1954 for all requirements. | 26·80 | | | | | | |
| 9 Percentage of samples conforming to I.S. 594—1962 for all requirements. | *Nil.* | | | | | | |

TABLE II.

*Showing the results of analysis of common salt samples taken from the private fish curing yards.*

| *Serial number and date.* (1) | *Particulars.* (2) | *Moisture.* (3) PER CENT. | *On dry basic.* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | *Insolubles.* (4) PER CENT. | *NaCl.* (5) PER CENT. | *MgCl.* 2 (6) PER CENT. | *CaCl.* 2 (7) PER CENT. | *Mg.Sa.* 4 (8) PER CENT. | *CaSo4* (9) PER CENT |
| 1 2nd December 1960. | Tuticorin Fish Curing Yard .. | 1·57 | 2·47 | 88·53 | 0·43 | .. | 0·14 | 3·17 |
| 2 2nd December 1960. | Do. | 6·20 | 9·70 | 80·57 | 3·32 | .. | 0·78 | 1·52 |
| 3 18th September 1962. | Aliyar Fish Curing Yard, Rameswaram. | 1·23 | 0·99 | 96·35 | 0·11 | .. | 0·12 | 1·30 |
| 4 18th September 1962 | Do. | 4·04 | 1·11 | 94·53 | 0·15 | .. | 0·40 | 2·77 |
| | | 3·26 | 1·32 | 89·99 | 1·00 | .. | 0·36 | 2·19 |

TABLE III.

*Showing the summary of the results of analysis of common salt samples offered for fish curing by the manufacturers in Madras State during the years* 1957–64.

| *Serial number and particulars.* (1) | *Moisture* (2) PER CENT. | *On dry basis.* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *NaCl.* (3) PER CENT. | *Insolubles* (4) PER CENT. | $MgCl_2$ (5) PER CENT. | $CaCl_5$ (6) PER CENT. | $MgSo_4$ (7) PER CENT. | $CaSo_4$ (8) PER CENT. |
| 1 Number of samples examined .. .. .. .. | 192 | 192 | 39 | 35 | 28 | 38 | 39 |
| 2 Range observed— | | | | | | | |
| Minimum .. .. .. .. .. .. .. .. | 0·00 | 81·2 | 0·02 | 0·04 | 0·014 | 0·03 | 0·0 |
| Maximum .. .. .. .. .. .. .. .. | 19·51 | 99·58 | 7·17 | 6·04 | 0·74 | 2·47 | 9·21 |
| 3 Average .. .. .. .. .. .. .. | 4·20 | 90·88 | 1·43 | 1·76 | 0·10 | 0·72 | 1·86 |
| 4 Number of samples conforming to I.S. : 594—1954 .. | 140 | 66 | 22 | 6 | | | |
| 5 Percentage of samples conforming to I.S. : 594—1954 .. | 72·91 | 34·37 | 56·41 | 15·38 | | | |
| 6 Number of samples conforming to I.S. : 594—1962 .. | 140 | 20 | 18 | 2 | | | |
| 7 Percentage of samples conforming to I.S. : 594—1962 .. | 72·91 | 10·41 | 46·15 | 5·13 | | | |
| 8 Percentage of samples conforming to I.S. : 594—1954 for all requirements. | (7·7 | | | | | | |
| 9 Percentage of samples conforming to I.S. : 594—1962 for all requirements. | 5·13 | | | | | | |

# THE FOULING ORGANISMS OF THE PEARL OYSTER FARM, KRUSADAI ISLAND, GULF OF MANNAR

BY

R. ANANTHANARAYANAN.

The pearl oyster farm of the Krusadai Biological Station is erected in a land locked area of the Kundugal channel situated in the head region of Gulf of Mannar. The sea is not always rough and the hydrobiological conditions are also favourable for the existence of the oysters (Chacko 1950 `1954 and 1952 Devanesam and Chidambaram.

In the pearl oyster farm of Krusadai Marine Biological Station wooden rafts, wooden cubicles and fabricated iron cages are used. These cages and cubicles are suspended over the rails planted in the channel in a depth of about six metres. Preliminary accounts of the organisms fouling the cages and cubicles have been made by Chacko, Kuriyan (1950) Kuriyan and Mahadevan.

In the site, observations were made from August 1962 to May 1963. The different kinds of organisms and their seasonal features are noted as given below :—

*Coelenterates*

Among the coelenterates the most common occurence as follows :—

Lytocarpus.—Abundant in April.
Mambranipora.— Do.
Obelia colonies.— Do.
Sertularia.—August.
Paranemonia.—March and April.

*Polyzoans.*—Nellia occulata, Bugula sps. Sedentary organisms like this found to attach on the wooden rafts as well as on the wire net.

Nellia occulata.—March and August.
Bugula.—April to August.

*Turbellaria.*—Turbellarians are frequently been blamed for the destruction of oysters. All are carnivorous. However it is probable that the turbellarians enter the oyster shell, only when it has sickened or died. In such a state the oyster is unable to work the adductor muscles to close the shell valves together. Then the turbellarians finishes off the victim, but anyway it is not to be blamed for the primary weakness. Planarians are the special visitors for the pearl oyster cages in the month of March and August.

*Annelida.*—Following were the annelidan members found in the cages. Lepidonotus Carinatulus, Dasychone Cingulata, Sebellastrate indica, Spirorbis, Oligochaeta and members of Syllidae. Dasychone cingulata (Sars).—March to August and December Sebellastrate indica—August.

Lepidonotus Carinatulus (Grube)—March and December.

*Arthropoda*

Mostly crustaceans—Balanus tintinnabulam (Linnaeus) usually found to attach on the wooden parts of the raft, because they prefer the flat sustratum. Lepas was also represented but when compared to Balanus they are lesser in number. Hippolysmata vittata (Stimpson) were the attractive visitors to the cages. Balanus tintinabulam (Linnaeus)—April to December. Hippolysmatta vittata (stimpson)—August to March. Alpheids—December.

*Decapods*

Some of the crabs were also found trapped inside the cages. They were Charybdis annulata (Fabricius) Thalamitta prymna, Thalamitta admitta (Nerbst) Polyonyx sps. Tylocracinus styx (Herbst) crabs were found throughout the year.

Besides that, numerous isopods and thousands of amphipods (Corophium) were also found sticking to the wire net. They occur almost through out the year.

*Mollusca.*—Members of the nudibranchs were the distinguished spectators in the pearl oyster cages. They were as follows :—

(1) Eolidina mannarensis.—March.
(2) Pleuroleura (Bergh) Striata.—March.
(3) Discodoris rubra.—April.
(4) Eulis (Cuthona) inornata.—March.
(5) Eolidina (Spurilla) neapalitana.—March.
(6) Eubranchus productus.—December.

*Bivalvia*

Modiolus sps. in thousands.—November.
Isognoman sps.—March.
Ostrea cuculata.—December.

*Echinodermata*

*Asteroidea.*—Pentaceras herdmani. Only once juvenile sps. of Pentacera sps. was found inside the cage.

*Echinoidea.*—Sea urchins are also rare. Only once juvenile sps. of salmacis virgulata (Agassiz) was collected inside the cage.

*Crinoidea.*—Sea lily. Two numbers were found inside the cage whose specific name could not be determined. They were collected during the month of April and August.

*Holothuroidea.*—Though the holothurians (edible sea cucumber) were commonly occuring inside the cages in the coast of Japan it was completely absent in the oyster cages at Krusadai.

*Tunicata.*—Some of the tunicata found to attach on the wooden rafts were white transparent, simple ascidians whose specific name could not be determined. The compound ascidians Diandracarpa of the genus branenhelmi (Michulson) found to attach on the upper side of the valves of the oysters. They almost choke the oysters. Hence periodical cleaning is necessary.

*Pisces*

The following two varieties of fishes were the common visitors to the oyster cage :—

1. Tetradon sps.
2. Petroskirtis leinardi.

*Sea weeds*

Some of the seaweeds were also found inside the cages almost throughout the year. The conspicuous genera of algae represented inside the cage were as follows:—

*Chlorophyceal*

1. Gracillaria.
2. Ulva lactuca.
3. Entersporpha sps.

*Pheophyceara*

1. Padina sps.
2. Sargassam sp.

*Rhodophyceae*

1. Ceramium sps.

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# STUDIES ON THE EXTRACTION AND PROPERTIES OF AGAR-AGAR FROM THE SEA-WEED GRACILLARIA SP. IN MADRAS STATE

BY

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## I. Introduction.

Agar-Agar is the complex polysaccharide occuring in large amounts along with cellulose in the cell walls of the seaweeds like *Gracillaria spp. Gelidium micropterum, Sarconema sp.* and *Hypnea sp*, and is in much demand in many industries. In the Food industry it is used in the preparation of jellies, desserts, salads, ice cream, jams, vegetable paste, and aerated waters and in the preservation and canning of meat and fish. In textiles, it is used as sizing medium for fabrics and as a thickener in drying and printing of textiles. In leather trade it is used as a sizing medium and in the fnished process of leather making. It is used in the manufacture of cosmetics, creams, soaps, shoe polish, hand lotions, quality adhesives, photographic films plywood, petroleum emulsion, plastic material for making dental imprints, marine storage, batteries, etc. graphite in an agar gel is used as a lubricant in the hot-drawing of tungsten wire for electric lamps. Agar also finduse as Activator in Nicotine sprays and in sizing of paper and electroplating of lead. In medicine, it is used as a laxative and as glycerine substitute as an ointment base and wound dressing. Above all the uses of agar in bacteriological work as a medium for the growth and culture of bacteria and in analytical and colloidal research are well known.

The most common agarophytes occuring in the coastal districts of Ramanathapuram Tirunelveli and Thanjavur in Madras State are *Gracillaria spp* and *Gelidium micropeterum*, which have been found to be valuable raw materials for the production of Agar-Agar by Bose et. al. (1943), Karunakar et. al. (1948), Chakraborty (1945), Thivy (1951), Mohanty (1956), and Chacko and Malu Pillai (1958) who employed different processes for the extraction of the agar. Thivy (1958) also worked out a Cottage industry method of manufacturing

Bacteriological agar from *Gracillaria edulis* (Gmel), Silva. Kappanna and Visweswara Rao (1963), studied the effect of different treatments of Gracillaria and Gelidium on the quality of the agar produced and standardized the conditions for the production of good quality agar. A series of experiments were also made by the present authors at the Fisheries Technological Station, Tuticorin, with a view to standardise the process of extraction of agar from the sea-weed *Gracillaria sp.* and to prepare a process flow chart for the commercial utilisation of the large quantities of the seaweed occuring in the State to manufacture Agar-agar on a pilot plant scale. The details and results of these experiments form the basis of this paper.

## II. Meterials and Methods

The sea-weeds *Gracillaria sp.* required for these experiments were collected from Pamban and Krusadai Islands, in Ramanathapuram district in Madras State. The weeds were sun dried and bleached according to the method described by Thivy (1961), before they were used for the experiments. The gel strength, setting temperature and melting temperature were determined with 1·5 per cent agar solutions as recommended by Wood (1946). Moisture, ash, acid insolubles, Nitrogen, Calcium and sulphates were determined according to the official methods of anallysis of the A.O.A.C. (1955).

## III. Details of Experiments

The methods adopted by the earlier Indian workers mentioned above for the extraction of agar formed the basis of the present series of experiments and various modifications were made in these methods in the different experiments with a view to find out the possibilities of increasing the yield of the agar and improving the quality of the product. The details of the various experiments conducted and the results obtained are described below :—

*Experiment No.* 1.—This is based on the Central Marine Fisheries Research Station Cottage Industry Method of Thivy (1958 lcc. cited), 250 grams of the clean, dry sun-bleached seaweed were washed in water and abrased in a mechanical stone grinder. 1,000 revolutions were made and the sea-weed was rinsed in 4·5 litres of water and filtered through filter cloth. The seaweed was again abrased in the stone grinder, making another 500 revolutions. Then soaked the seaweed in 12 litres of water, filtered, ground to paste and the paste again soaked in 12 litres of water for 24 hours. The paste was dried, the dried paste weighing 163 grams i.e., 65 per cent of the weight of the dried sea-sweed. The dry pulp was added to 7·5 litres of boiling water and boiling continued for 45 minutes. Filtered hot and the filtrate cooled to form a gel, the supernatent gel removed from the sediment, melted in a waterbath and recooled to form a gel, cut into strips and dried on plastic wire mesh screens in the sun. No freezing or thawing was done. The residue left in the first extraction was used for the second extraction as described by Thivy.

*Experiment No.* 2.—This is a modification of the method followed in Experiment No. 1, in that the gel formed in the first and second extractions were purified by freezing and thawing the product.

*Experiment No.* 3.—This is a repetition of Experiment No. 2.

*Experiment No.* 4.—One kilogram of the clean, dry, bleached sea-weed was washed in hot water and ground to pulp in a mechanical wet grinder. The ground pulp was then added to 30 litres of boiling fresh water in an open vat and the boiling continued for another 45 minutes . Filter the boiling liquid through a filter cloth while still hot, collecting the filtrate in trays. Allowed the filtrate to cool to a gel, frozen in a deep freezer for 40 hours, thawed and dried in air-oven. The residue after the extraction was again utilized for second extraction and was added to 15 litres of boiling fresh water and the process repeated as above. The yield in the second extraction was noted and the properties of the product studied separately.

*Experiment No.*5—500 grams of the clean dry, bleached sea-weed were soaked in water for four hours, washed, ground to paste in a mechanical wet grinder and added to 24 litres of boiling fresh water. At this stage, 40 c.c. of N. $H_2 So_4$ was added to the boiling solution to bring down the pH of the medium to 6·0 and the boiling continued for 45 minutes. Filtered the boiling solution while still hot through a filter cloth, collecting the filtrate in trays. Allowed the filtrate to cool to a firm gel, frozen in a deep freezer, thawed, and dried in air-oven.

*Experiment No.* 6.—Experiment 2 was repeated and a second extraction was also made, boiling the residue of the first extraction in 20 litres of dilute $H_2 So_4$ at a pH of 6·0 and repeating the subsequent processes as before. The yield of the second extraction was noted and the properties of the product studied separately.

*Experiment No.* 7.—Method is the same as in experiments 5 and 6 but the ground pulp was soaked in fresh water for 24 hours and then dried before extraction.

*Experiment No.* 8 *and* 9.—Procedure is the same as in experiment 7, but the ground pulp after soaking for 24 hours, was straight away used for extraction without drying.

*Experiment No.* 10.—1·5 kg. of the clean, dry, bleached seaweed was well powdered in a Raymond Laboratory Mill worked by ½ horse power motor and the powder was well washed with water and then ground to paste in a mechanical wet grinder. The ground pulp was added to 60 litres of boiling fresh water along with 180 ml. of N. $H_2 So_4$ and the boiling continued for four hours. Filtered hot through filter cloth, the filtrate cooled to form gel, cut into strips, frozen, thawed and dried in a hot current of air at 50°C in a tunnel drier.

*Experiment No.* 11.—The procedure is the same as in experiment 10, but the powdered sea-weed after washing, was straightaway extracted, without grinding to paste.

## IV. Results and discussions

The results of the eleven experiments are detailed in Annexure I which shows the yield of agar in each experiment and the gel strength, setting temperature, melting point, moisture, ash, acid insolubles, nitrogen, calcium and sulphate contents of the agar samples obtained in each experiment. The properties and composition of commercial samples of Japanese and Difco agar are also shown in this Annexure for comparison.

In the first three experiments in which the Central Marine Fisheries Research Station Cottage Industry method was followed, the yield of agar ranged from 20 per cent to 33·5 per cent only as compared with the yield of 46 per cent reported by Thivy (1961. loc. cited). The gel strength of the agar obtained was also as low as 60 g; but it could be improved and the ash, acid insolubles, mineral constituents and nitrogen content of the agar could be considerably reduced by freezing and thawing the product as can be seen from the experiments 2 and 3. This is in conformity with the observations of Kappanna and Visweswara Rao (1963 loc. cited). In experiment 4, where the repeated soaking of the weeds and the ground paste for several hours in water was avoided, the gel strength of the product was found to improve, as reported by Wood (1946. loc. cited). In experiments 5 and 6, where the extraction was done at a pH of 6·0 by the addition of $H_2 So_4$ to the boiling solution, the yield was found to improve much and the product had a comparatively high gel strength. Soaking of the ground pulp in water for 24 hours, before extracting at a pH of 6·0 as done in experiments 7, 8 and 9 decreased the yield considerably and so it was decided to avoid soaking. Maximum yields of agar of 33·33 per cent and 37 per cent with gel strengths of 141 g. and 156 g. respectively were obtained in experiments 10 and 11, where the clean, dry, bleached sea-weed was first disintegrated into fine powder in a laboratory mill and the extraction done at pH of 60 by the addition of sulphuric acid, as reported by Kappanna and Visweswara Rao (1963 loc. cited). The agar produced in the last two experiments compared favourably with the commercial samples of agar now being sold in the market both in appearance and in composition and properties as can be seen from the figures in Annexure I. Repetition of Experiment No. 11 a number of times gave consistantly good yield of agar of high gel strength and so the process adopted in this experiment may be taken as the standard one.

Based on the experiments described above, the process flow chart shown in Annexure II may be adopted for the commercial utilisation of the seaweed *Gracillaria sp.* occurring in the coastal districts of Ramanathapuram, Thanjavur and Tirunelveli in Madras State for production of Agar-agar on a pilot plant scale.

The required raw materials namely *Gracillaria sp.* may be collected during their maximum growth from June to December, every year by employing labour. The collected weeds should be washed well in sea-water and dried in the sun on mats for 3 days, sprinkling sea-water over the weeds daily morning. The dried weeds should be washed well in fresh water several times and again sun-dried on mats, sprinkling fresh water daily morning. The washing in fresh water and drying should be continued until the weeds are completely bleached. The resultant clean, dry, bleached sea-weed should be stored in a well-ventilated room and used as and when required in small lots for further processing operations. Thivy (1961, loc. cited) has estimated that in the Pamban area of Ramanathapuram district in Madras State, about 40·6 tonnes of fresh *Gracillària spp.* can be harvested annually to yield about 5·1 tonnes of dry sea-weeds. It may be possible to harvest further quantities of this agarophyte from other coastal villages between Point Calimere and Cape Comorin to procure the required raw material of 10 tonnes/annum to feed a pilot Agar Plant of capacity 30kg. (raw material) daily.

This pilot plant may require equipments like one disintegrator for finely powdering the dried and bleached seaweeds, one steam jacketted open pan type S.S. evaporater one steam jacketted S.S. filtration unit, one steam boiler to supply steam for the evaporater and filtration units, a number of S.S. Setting trays for allowing the agar gel to form Plastic or Nylon wire mesh screens to dry the agar strips, one ice plant or big freezing cabinets for freezing the agar gel, one temperature controlled cabinet drier for drying the frozen and thawed agar at 50°C in hot air and one micro-pulveriser for powdering the agar. All these equipments are available in our country and may cost about Rs. 1 lakh in all. The expenditure on these items may be reduced if the pilot plant for agar is put up in a place like Tuticorin where the State Government has already put up a 5 tonne ice plant and a Fish Canning Factory with a Steam Boiler, so that these costly equipments could be suitably made use of for the Agar plant also. Another essential requisite for the location of this plant will be the availability of copious supply of fresh water for the bleaching operations of the seaweed and for further washing and extraction operations. About 1,000 gallons of fresh soft water may be required daily to handle 30 kg. of the dried sea-weed.

This pilot plant will be able to produce about 10 kg. of agar per day or about 3 tonnes of agar/annum, which will be approximately our country's requirements at present. The agar requirements of our country are at present mostly met by imports from Japan, U.S.A. and other countries and their prevailing market rates vary from Rs. 40 to Rs. 220 kg. depending on the quality of the product. The setting up of an agar plant in Madras State may help to save foreign exchange to the tune of Rs. 2 lakhs besides finding a good use for the sea-weed resources of the State. It has been computed that based on the process flow chart detailed above, the cost of production of agar-Agar will come to less than Rs. 20 per kg. only and so the establishment of a pilot plant for manufacture of agar will also be a profitable venture.

### *Acknowledgments.*

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### ANNEXURE I.

*Showing the yield and properties of Agar obtained in the various experiments.*

| *Experiment number and Method used for extraction.* | *Proportion of seaweed water used.* | *Yield.* | *Gel. strength (gms.)* | *Setting temp. (C°)* | *Melting temp. (°C)* | *Moisture* | *Ash.* | *Acid Insolubles.* | *N2* | *Ca* | *So4* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| | | PER CENT. | | | | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. | PER CENT. |
| | | | | | | | | | (on dry basis). | | |
| 1 C.M.F.R.S. Method (Thivy 1958, loc. cited) . . | 1:30 | 28 | 60 | 40 | 81 | 17·4 | 11·17 | 3·5 | 0·3100 | 1·99 | 2·4000 |
| 2 C.M.F.R.S. Method as in Experiment 1 but the Gel purified by freezing and thawing. | 1:40<br>1:40 | 15<br>5 | 70<br>100 | 39<br>. . | 80<br>. . | 17·00<br>14·10 | 6·2<br>5·2 | 1·37<br>1·10 | 0·060<br>. . | 1·30<br>. . | 2·98<br>. . |
| 3 Do. | 1:40<br>1·40 | 28<br>5·5 | 65<br>63 | 40<br>. . | 79<br>. . | 17·12<br>13·00 | 6·7<br>7·69 | 2·6<br>3·4 | 0·194<br>. . | 1·38<br>. . | 2·97<br>. . |
| 4 Seaweed after washing, ground to pulp in wet grinder and added to boiling water and boiled for 45 minutes Filtered, cooled to Gel frozen, thawed and dried in air-oven. | 1:30<br>1:15 | 15<br>11 | 121<br>65 | 42<br>. . | 81<br>. . | 17·4<br>17·4 | 10·92<br>11·73 | 3·92<br>2·34 | 0·288<br>. . | 1·977<br>. . | 1·73<br>. . |
| 5 Soaked in water for 4 hours, ground to paste in wet grinder, added to boiling water, Sulphuric Acid added to bring pH to 6·0 and boiling continued for 45 minutes, filtered, cooled to gel. frozen, thawed and dried. | 1:48 | 25·5 | 115 | 42 | 81 | 16·18 | 10·74 | 2·63 | 0·298 | 1·82 | 1·78 |
| 6 Same as Experiment 5 but second extraction also done. | 1:48<br>1:40 | 23<br>14 | 102<br>70 | 41<br>. . | 81<br>. . | 18·58<br>16·25 | 14·45<br>19·01 | 5·84<br>7·501 | . .<br>. . | 1·59<br>. . | 1·74<br>. . |
| 7 Same as Experiments 5 and 6 but the ground pulp soaked for 24 hours and dried before extraction. | 1:40 | 16 | 169 | 39 | 79 | 13·48 | 13·58 | 2·89 | 0·09 | 1·405 | 3·4 |
| 8 Same as Experiment 7 but no drying of the pulp before extraction. | 1:40 | 21 | 128 | 39 | 81 | 21·9 | 14·96 | 1·18 | 0·119 | 1·51 | 3·41 |
| 9 Same as Experiment 8 but second extraction done. | 1:48<br>1:40 | 16<br>8 | 129<br>126 | . .<br>. . | . .<br>. . | 17·3<br>16·19 | 5·9<br>3·4 | 0·193<br>0·161 | 0·32<br>. . | 2·009<br>. . | 3·567]<br>. . |
| 10 Seaweed powdered finally in a laboratory mill before extraction and ground to paste in a wet grinder before extraction as per experiment No. 8. | 1:45 | 33·33 | 141 | 40 | 79 | 20·6 | 6·504 | 1·767 | 0·305 | 1·89 | 2·335 |
| 11 Seaweed well powdered in laboratory mill and straight away extracted as per Experiment No. 8. | 1:60 | 37 | 156 | 42 | 79 | 19·72 | 7·718 | 1·858 | 0·298 | 1·727 | 3·654 |
| 12 Commercial Agar Samples— | | | | | | | | | | | |
| (i) Japan Agar (used for Bacteriological work). | . . | . . | 245 | 38 | 85 | 19·96 | 3·378 | 0·420 | 0·15 | 1·36 | 3·897 |
| (ii) Bapco agar (Japanese) Kappanna and Visweswara Rao (1963, loc. cited). | . . | . . | 75 | 38 | 86 | 17·13 | 2·28 | . . | 0·16 | 0·56 | 1·50 |
| (iii) Difco agar, (Kappanna and Visweswara Rao (1963, loc. cited). | . . | . . | 55 | 38 | 89 | 18·91 | 3·02 | . . | 0·16 | 0·30 | 2·02 |

## Annexure II.

*Process Flow Chart for Production of Agar-Agar* (10 *kg*).

Red Sea-weed (*Gracillaria spp.*) Wet wt. 250 kg.

Wash Well in Sea-water and Sun-dry for 3 days, sprinkling sea-water daily morning.

Washed several times in fresh water and sun-dry on mats with repeated sprinkling of fresh water until bleached completely and dried (30 kg.)

Pulverise into fine powder in Disintegrator.

Rinse the sea-weed powder in fresh-water.

Extract the powder in boiling fresh-water (1,200 litres) in an open S.S. Evaporater for 4 hours, at pH 6·0 by addition of about 3 litres of N. $H_2So_4$.

Filter the Hot extract in S.S. Steam Jacketed Filter.

Allow the Filtrate to set to gel in S.S. Trays.

Cut the gel into Strips.

Freeze the gel in a freezer or ice plant for 24 hours.

Allow the Frozen Gel to thaw.

Dry in a current of Hot Air at 50°C in a Drier.

Powder the Dried Agar in a Mechanical Pulveriser.

Pack in Polythene Bags or Tins. (Agar-Agar) 10 kg.

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